2016 Status Report

Falls Lake Nutrient Strategy

Cedar Creek Arm, Falls Lake

For the March 10, 2016 Meeting
of the N.C. Environmental Management Commission

Developed by the N.C. Division of Water Resources
Nonpoint Source Planning Branch

Water Resources
ENVIRONMENTAL QUALITY

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Recommended citation:

Division of Water Resources Nonpoint Source Planning Branch (2016). 2016 Status Report: Falls Lake Nutrient Strategy. N.C. Department of Environmental Quality. Raleigh, NC.

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Executive Summary

The Falls Lake Nutrient Management Strategy, also referred to as the Falls rules, is a comprehensive set of rules implemented in January 2011 to reduce nitrogen and phosphorus inputs to Falls Lake. These nutrients contribute to the lake exceeding the state's chlorophyll *a* standard, which was adopted in the 1970's pursuant to the Clean Water Act and serves to protect the designated uses of waterbodies like Falls Lake. These uses include water supply, fish and wildlife propagation, flood control, and recreational uses.

The Falls rules require the Division of Water Resources to report to the Environmental Management Commission on specific aspects of progress in the Falls Lake watershed in January 2016 and every five years thereafter. This report satisfies that requirement by providing an update on implementation of the rules, evaluating changes in nutrient loading to the lake, detailing progress towards achieving the chlorophyll *a* water quality standard, and characterizing advances in scientific understanding and control and accounting technologies while identifying future research and data needs.

The Army Corps of Engineers recommended Falls Lake for construction in 1963, primarily for flood control, and it was approved for construction by Congress in 1965. Primary benefits of the lake included control of persistent riverine flooding and enhancement of drinking water sources. Other projected advantages included the protection of downstream water quality, fish and wildlife conservation, and recreation. Pre-construction assessments of the project conducted by the US Army Corps of Engineers (USACE 1974) and the State of North Carolina Department of Natural and Economic Resources Office of Water and Air Resources (1973) predicted that algal blooms would occur in the upper part of Falls Lake, and that this part of the lake would not meet water quality standards. The assessments concluded that the benefits of the lake would outweigh the risks associated with algal blooms.

Excessive nutrient inputs in Falls Lake have the potential to result in increased costs to treat drinking water, and perhaps impact the aesthetic enjoyment of the lake-based on recreation. Because Falls Lake serves as Raleigh's primary drinking water source and a regional driver of tourism at the Falls Lake State Recreation Area, these concerns could potentially impact the regional economy.

The Falls Lake management strategy incorporates nitrogen and phosphorus reduction estimates that were derived from water quality models that include scientific uncertainty. At the time modeling was conducted, the water quality data available to develop and calibrate the models was limited and the Division of Water Resources did not have the resources or the time to conduct additional studies to address key data gaps. The Falls Lake strategy acknowledges the uncertainty associated with the modeling and allows for a reexamination process including the development of supplemental models which can be used as the basis for future revisions to the Falls Lake reduction goals and changes to the strategy. The Upper Neuse River Basin Association (UNRBA) is currently investing $800,000 per year to conduct monitoring studies in order to reduce this scientific uncertainty. The UNRBA is conducting enhanced water quality assessments in the watershed and the tributaries feeding the lake. Furthermore, targeted special studies are underway with the aim of addressing specific modeling questions such as the contribution of nutrient loading from lake sediments and the significant loading to the lake that occurs during storm events.

The Falls Lake strategy differs from other state nutrient strategies in two key respects. First, an unprecedented degree of nutrient reduction is projected to be needed to achieve the chlorophyll a water quality standard in the lake. The rules, based on an estimate of the 2006 modeled condition, require all major sources of nutrients in the watershed to reduce their nitrogen and phosphorus loads by 40 and 77 percent, respectively. Compounding this challenge, the Neuse nutrient strategy and other regulations have previously implemented many measures that would otherwise be available to advance Falls Lake nutrient reduction goals. As a result, reduction needs faced by most sources challenge the limits of current technology and will impose significant costs.

Given the unprecedented degree and achievability of the projected nutrient reductions required, as well as the inherent uncertainty of all modeling used to establish reduction goals, the Falls rules respond to these challenges by invoking a staged, adaptive implementation process. Stage I is 10 years in length, through 2020, with the objective of meeting the chlorophyll *a* standard in the lower lake. With the exception of existing development which is required to offset nutrient loads back to baseline levels, Stage I of the rules calls for achieving half of full strategy reductions, or nitrogen and phosphorus reductions of 20 and 40 percent, respectively, from sources. Stage II calls for additional reductions in the upper watershed with the overall goal of achieving all reductions and meeting the chlorophyll *a* standard throughout the lake by 2041. Regulated sources are new and existing development stormwater, wastewater dischargers, agriculture, and state and federal entities stormwater. At the current halfway mark in Stage I implementation, regulated sources are realizing required nutrient reductions and the lake is showing progress towards meeting the chlorophyll *a* standard in the lower lake. Division analyses show fewer exceedances of the chlorophyll *a* standard in the lower lake compared to pre-strategy conditions. Modest improvements are also seen in the upper lake. Under the strategy, when an impaired segment of the lake complies with the chlorophyll *a* water quality standard for two consecutive use support assessments, no further load reductions will be required. The 2014 use support assessment showed the lower lake meeting the chlorophyll *a* standard. Results of the next assessment cycle are expected in April 2016.

To assess changes in annual nutrient loading to the lake for this report, the Division evaluated ambient water quality and flow data entering the lake from the upper five subwatersheds for 2006 through 2014. This analysis included large variations in rainfall and runoff flow between years. Results were mixed, with a 55 percent decrease in total phosphorus loading and a 20 percent increase in total nitrogen loading. The nitrogen increase, however, could be misleading as 2014 was a wet year with inflows 60 percent above 2006 levels, suggesting the possibility that given a comparable flow year, nitrogen loads may take a different direction. Under this thinking, the 55 percent phosphorus reduction in a high flow year is all the more striking an achievement. Phosphorus loading reductions are largely attributable to phosphorus reductions by the three major municipal wastewater treatment plants in the upper Falls watershed. Reductions from agriculture and new development may also have played into these trends.

Point sources are required to achieve a 20 percent nitrogen reduction and 40 percent phosphorus reduction by 2016. As of 2014, the three major wastewater dischargers have already reduced their combined nitrogen load by 20 percent and their phosphorus load by 67 percent. While two of the three plants have invested considerably in upgrades during Stage I, much of the load reductions were made through improved management of existing treatment technology.

Reductions have been made by nonpoint sources as well. Beginning in mid-2012, local governments implemented new development stormwater ordinances that require developers to meet nutrient export targets that embody the strategy reduction goals relative to average pre-development loading. As a gauge of development activity, through June 2015, 50,766 pounds of nitrogen and 3,645 pounds of phosphorus offset credits were purchased as part of meeting new development requirements. In addition, new development projects are also required to meet a portion of their nutrient load reduction requirements onsite. The agriculture community also estimates substantial reductions. Reports are submitted annually to the Division, and the 2015 report estimates reductions in agricultural nitrogen loss of 35 percent through crop year 2013.

Existing development stormwater rule requirements have been delayed by mutual agreement with the local governments. Under the rule, local governments are required to reduce nutrient loading from lands developed between 2006 and 2012 back to baseline levels by 2021. However the process of expanding the toolbox of creditable practices has required additional time. The Division and the Upper Neuse River Basin Association (UNRBA) are working collaboratively on this effort. The Division plans to bring a final model program with a fuller set of measures for Commission approval within the next two years. Concurrently in the ongoing rules readoption process, the Division has proposed extending the Stage I deadline for existing development to 2025 to restore sufficient implementation time to meet the targets.

The latest information regarding changes in atmospheric nitrogen deposition is positive. Recent air quality modeling shows a reduction in total nitrogen deposition in the Falls watershed of 15 percent since the 2006 baseline. The expected maturation of prior air quality initiatives and new ones in progress suggest further reductions are likely. Loads from atmospheric deposition not only contribute directly to the lake surface, but also deposit to land surfaces which are subsequently washed off during precipitation events.

To date, the Falls Lake strategy has been largely effective. Implementation has generally proceeded in a timely fashion, and nutrient loading and water quality metrics are generally improving.

The water quality of Falls Lake ultimately hinges on the continued willingness of affected parties to work towards the achievable Stage I goals even as feasibility concerns remain regarding Stage II. The regulated community, including the UNRBA and the local governments it represents, continues to work constructively and collaboratively with the Division. Their partnership has been essential and invaluable in addressing the formidable challenges inherent in the sustaining the resources and designated uses of Falls Lake.

Introduction

Scope of Report

Pursuant to the Falls Lake Nutrient Management Strategy's Purpose and Scope rule, the Division is charged with providing the Commission an update every five years on not only lake progress but more so on advances being made in supporting science, control technologies, management practice and accounting systems. The information to be addressed is wide-ranging; the applicable section of rule text is provided in Appendix I. The rule calls for the Division to work in collaboration with and include information provided by local governments and other interested parties in developing these reports, and staff has done so for this report as identified in the acknowledgements section following the title page. This report is the first of many scheduled during implementation of the Falls strategy. Presently, the planned date of attainment of the chlorophyll *a* standard throughout Falls Lake is 2041.

The remainder of the report is presented in five sections. After a general overview, status of strategy implementation is provided rule by rule. This is followed logically by an assessment of water quality metrics regarding the lake's response to implementation to date. The largest section of the report follows, providing updates regarding advances on a broad array of watershed restoration sciences, ranging from atmospheric deposition of nitrogen to groundwater nutrient studies, control technologies, management practice and compliance accounting systems. Finally, the Division offers some brief parting thoughts regarding the continuing implementation of the Falls Lake strategy moving forward.

About Falls Lake

Overview

Falls of the Neuse Reservoir, also known as Falls Lake, is an impoundment that covers 12,400 acres in Wake and Durham Counties. The lake is located in the upper Neuse River Basin, which drains a mixture of forested, agricultural, and urbanized lands. It serves as the primary drinking water source for Raleigh and surrounding communities including Garner, Rolesville, Wake Forest, Knightdale, Wendell, and Zebulon. The City of Raleigh's E.M. Johnson Water Treatment Plant receives water directly from lower Falls Lake, presently drawing approximately 47 million gallons per day (City of Raleigh, 2015).

Falls Lake is also a premier recreation destination for residents of North Carolina and visitors from afar. Falls Lake State Recreation Area, one of 42 units in North Carolina's State Parks system, encompasses more than 5,000 acres and hosts approximately one million visitors annually. Water-dependent uses include five swim beaches as well as expansive boating and fishing opportunities. Other parks bordering Falls Lake include the 236 acre Blue Jay Point (Wake) County Park and Penny's Bend Nature Preserve, home to more than 460 plant species. Addressing growing recreational demands near the lake, the City of Raleigh is scheduled to open the 586-acre Forest Ridge Park in 2016.

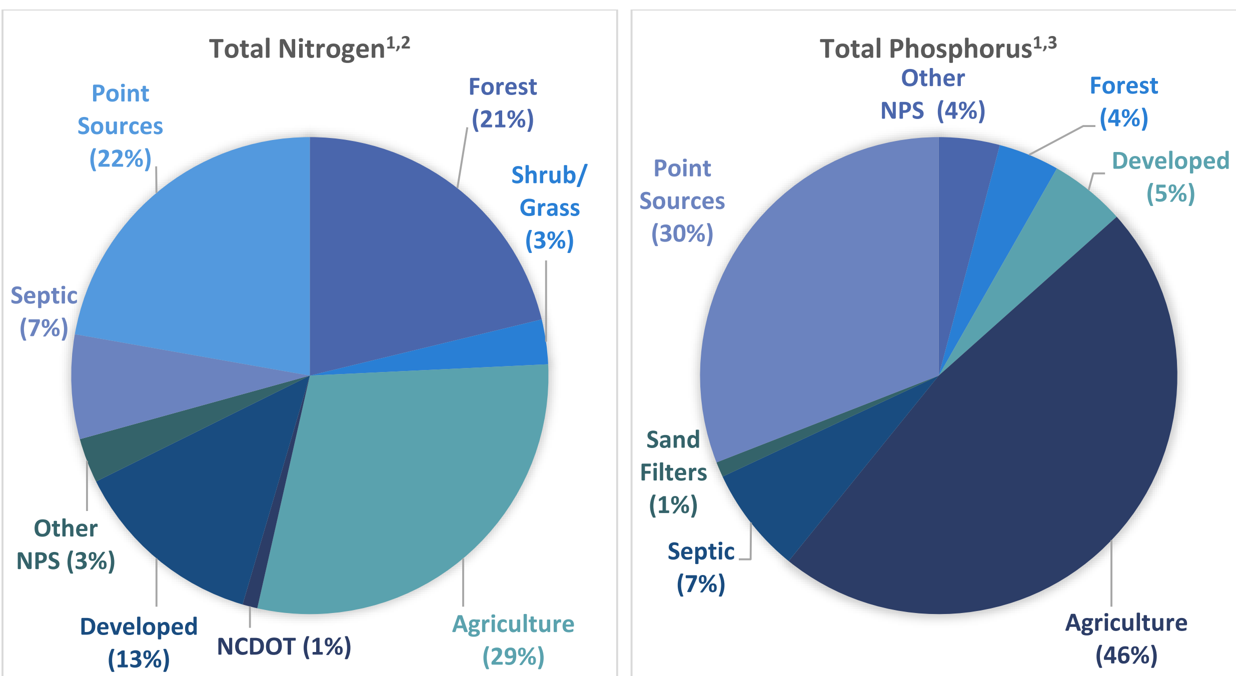
The watershed draining to Falls Lake covers 770 square miles in six counties, including portions of Raleigh and Durham. Over 90,000 people reside here. Annual population growth in the Raleigh-Durham-Cary combined statistical area is 1.9 percent, which rates among the top ten growth rates in the country. Falls Lake is the largest of nine water supply reservoirs in the Falls Lake watershed serving at least 450,000 people (Division of Water Quality Basinwide Planning Unit, 2009).

TABLE 1. SUMMARY OF LAND COVER IN FALLS LAKE WATERSHED (2001 AND 2011 NATIONAL LAND COVER DATASET).

Aggregated Land Cover Type	2001 (acres)	Percent of watershed	2011 (acres)	Percent of watershed	Change (acres)	Percent change
Developed	65,600	13%	72,600	15%	7,000	11%
Forest	286,000	58%	273,800	55%	-12,100	-4%
Agriculture	85,700	17%	83,700	17.0%	-2,000	-2%
Other	56,400	11%	63,600	13%	7,100	13%

The Falls watershed model estimated the proportion of total nitrogen and total phosphorus loads to Falls Lake from a variety of different sources and land use types in the upper Falls watersheds. Based on this 2006 analysis, agriculture and point sources were the two most significant sources of both nitrogen and phosphorus to the lake (Figure 1).

FIGURE 1. ESTIMATED PROPORTIONS OF NITROGEN AND PHOSPHORUS LOADING SOURCES FROM UPPER FALLS WATERSHED TO FALLS LAKE (2006).



[1] Due to rounding, totals do not equal 100%
[2] Other sources that contribute less than 1% of nitrogen loading include wetlands, sand filters, sanitary sewer overflows, and air deposition.
[3] Other sources that contribute less than 1% of phosphorus loading include shrub/grass, NCDOT, wetlands, and sanitary sewer overflows.

Significant economic benefits are expected as water quality in Falls Lake improves. The fiscal analysis prepared in support of the Falls Lake strategy identified between $179 million and $336 million in recreational benefits resulting from cleaner water in Falls Lake (in 2010 dollars over 30 years). Further independent analyses in 2013 using a range of scenarios estimate recreational benefits between $469 million and $903 million (von Haefen, 2013). The fiscal analysis also estimated avoided costs for advanced drinking water filtration technologies ranging between $43 million and $266 million. Other benefits of a clean Falls Lake include higher local property values, enhanced economic recruitment to the region, and improved commercial and recreational fisheries in downstream rivers and estuaries (Division of Water Quality Planning Section, 2010). Noting that recreational benefits account for approximately half of the total benefits of environmental regulation in other studies, von Haefen offers a "crude estimate" of between $938 million and $1.8 billion in benefits from the Falls Lake strategy.

The Falls Lake strategy also incurs significant costs. According to the fiscal note prepared in support of these rules, costs to fully implement the strategy are estimated at up to $1.5 billion. While noting the conservative (high) valuation of these costs, von Haefen concluded that "it is uncertain whether the FLNMS will generate benefits greater than costs over the next 25 years." It should be noted that benefits on the whole are generally more difficult to monetize than costs particularly in the realm of environmental economics, and to date quantitation of environmental benefits remains underdeveloped, suggesting caution in interpreting cost-benefit projections.

History

Proposals to create Falls Lake were discussed as early as the 1930s. The Army Corps of Engineers recommended Falls Lake for construction in 1963 and it was approved for construction by Congress in 1965. Primary benefits of the lake included control of persistent riverine flooding and enhancement of drinking water sources. Other projected advantages included the protection of downstream water quality, fish and wildlife conservation, and recreation. Pre-construction assessments of the project conducted by the US Army Corps of Engineers (USACE 1974) and the State of North Carolina Department of Natural and Economic Resources Office of Water and Air Resources (1973) predicted that algal blooms would occur in the upper part of Falls Lake, and that this part of the lake would likely not meet water quality standards. The assessments concluded that the benefits of the lake would outweigh the risks associated with algal blooms.

Falls Dam was completed in 1981 after three years of construction. Soon thereafter water quality problems became evident. In 1983 the Environmental Management Commission gave Falls Lake the Nutrient Sensitive Waters designation. Protection steps began in the 1990s through point source restrictions on nutrient dischargers in the watershed.

Public interest in Falls Lake heightened around 2004. The Division began enhanced monitoring to assess whether the lake was meeting water quality standards. The state also began to develop specific lake and watershed models. In 2005 the General Assembly required the Commission to adopt a nutrient strategy for Falls Lake. Subsequent legislation in 2009 established a deadline for this task, resulting in the development and implementation of the Falls Lake strategy by 2011.

Based on water quality data collected between 2002 and 2006, Falls Lake was listed as impaired for chlorophyll *a* on North Carolina's 2008 303(d) list, required by the EPA pursuant to that section of the Clean Water Act. The green pigment chlorophyll *a* is a measure of algal productivity, which is stimulated by nutrient inputs to the lake. The 303(d) list is a list of impaired waters that are not meeting water quality standards and require a Total Maximum Daily Load or an alternate pollution reduction strategy. The portion of the lake above interstate I-85 was also listed for turbidity.

To formulate a strategy to attain the chlorophyll *a* standard in Falls Lake, the Division held a series of ten stakeholder meetings and twelve subcommittee meetings from August 2008 to January 2010. The Division then provided draft rules for public comment in summer 2010. Two public hearings were attended by over 200 people. The Commission assigned three hearing officers to evaluate the input.

During the comment period, the Division received comments from 629 individuals and organizations. The hearing officers reviewed these comments and weighed input from the stakeholder teams, potentially affected parties, local governments, legislators, concerned citizens, interest groups, and Division staff to arrive at recommended final rules. The Division presented the final rules to the Commission in November 2010 for adoption and subsequent approval by the Rules Review Commission in January 2011.

FIGURE 2. BASELINE LAND COVER MAP IN THE FALLS LAKE WATERSHED (SOURCE, 2011 NATIONAL LAND COVER DATASET).

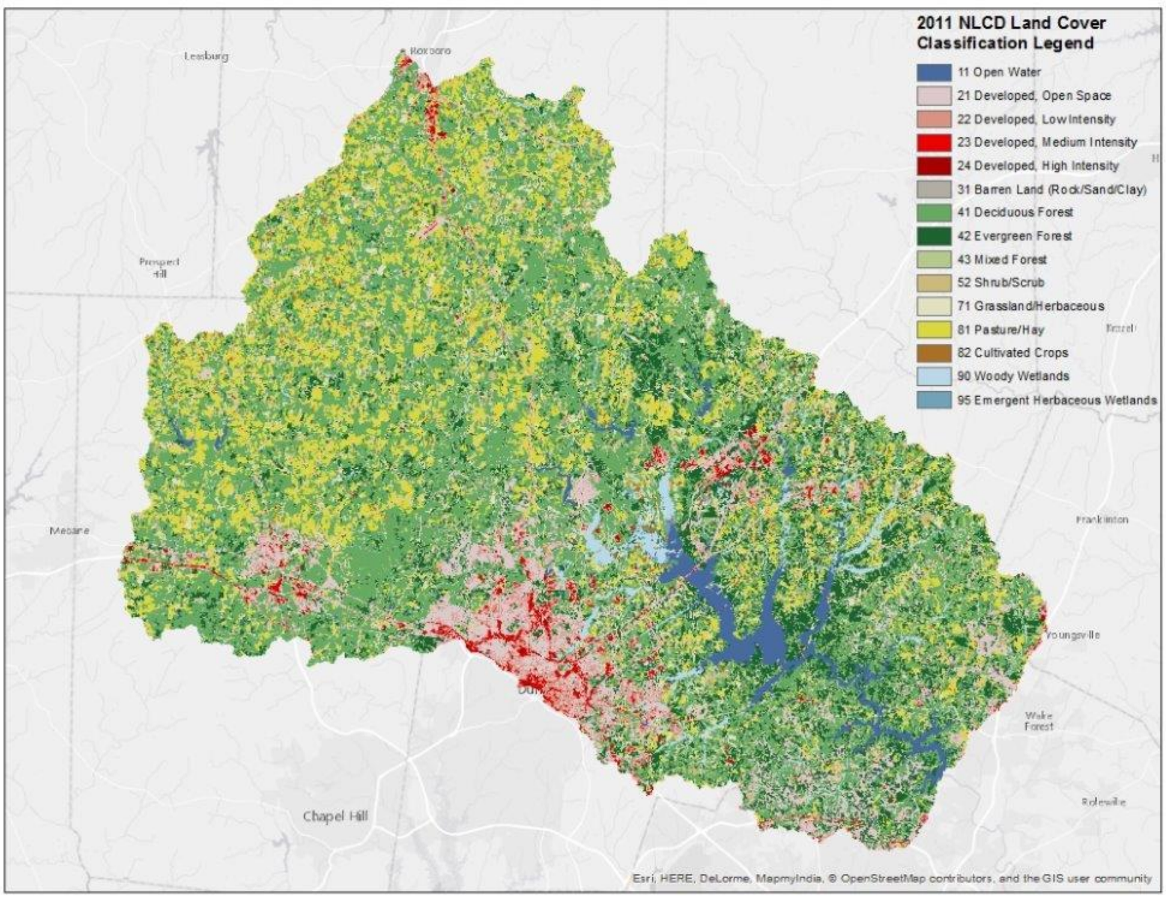
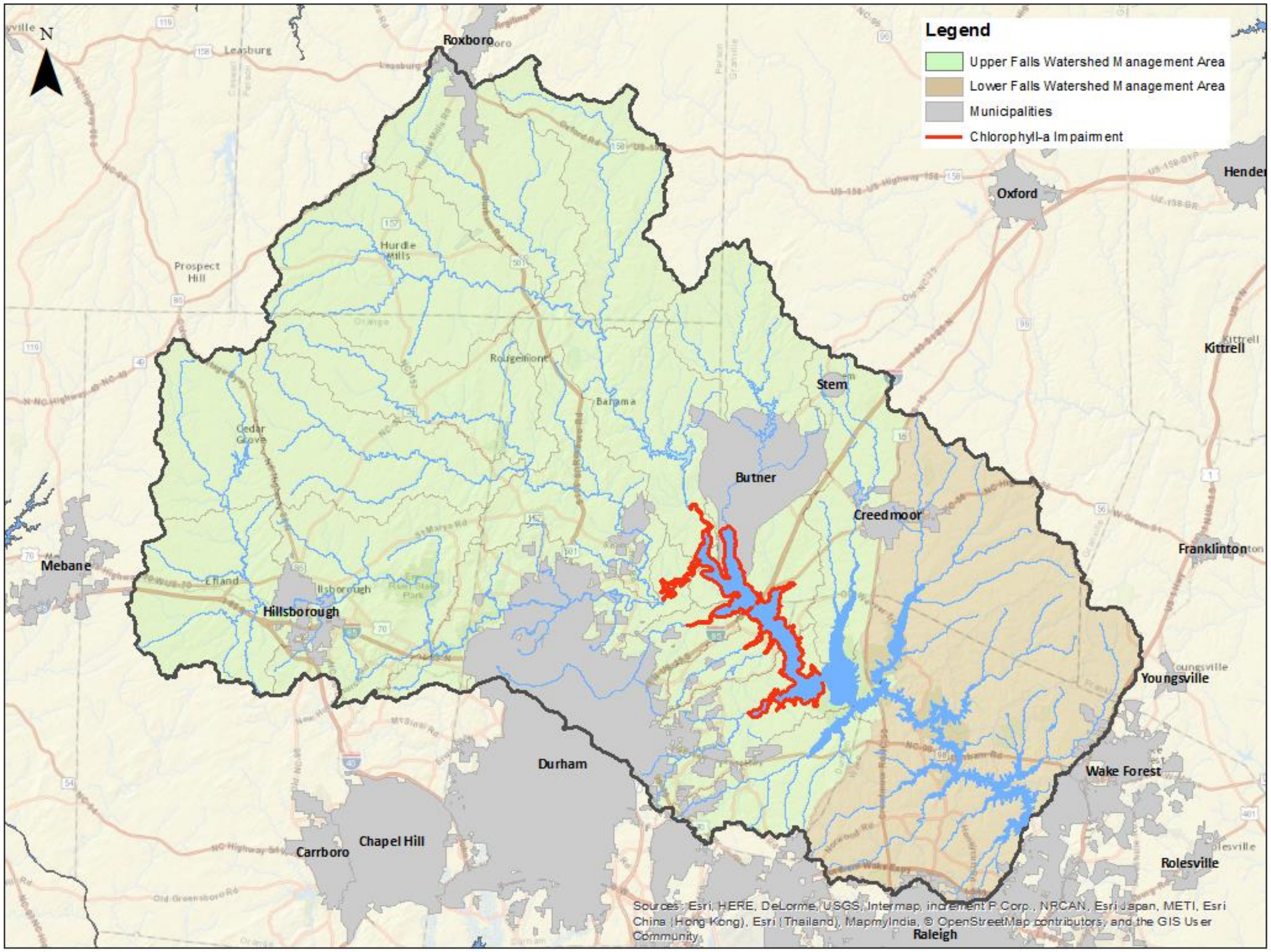


TABLE 2. FALLS LAKE TIMELINE.

Year	Event
1930s	State of North Carolina requests a study for creating Falls Reservoir
1959	Neuse River from mouth of Little Creek to Wake Finishing Plant (encompassing present Falls Lake) receives water supply classification (A-II).
1963	Army Corps of Engineers recommends Falls Lake for construction
1965	Congress authorizes construction of Falls Lake with Flood Control Act of 1965
1973	N.C. Department of Natural and Economic Resources Office of Water and Air Resources releases its Special Analysis of the Falls of the Neuse Project
1974	Army Corps of Engineers releases its Final Environmental Impact Statement (Revised) Falls Lake Neuse River Basin North Carolina
1978	Falls Lake construction begins
1979	Statewide chlorophyll *a* standard adopted
1981	Falls Lake construction complete
1983	Falls Lake water levels reach present day normal levels
1983	Falls Lake designated as Nutrient Sensitive Waters (NSW), water supply designations expanded to include Falls Lake.
1989	Water supply protections mandated in North Carolina, S.L. 1989-426
1992	Falls Lake classified as a water supply watershed
1997	S.L. 1997-458 caps nitrogen and phosphorus wastewater outputs into NSW
2004	Division monitoring and modeling studies of the lake begin
2005	Session Law 2005-190 requires the Environmental Management Commission to adopt a nutrient strategy for Falls Lake
2005	Falls Lake Technical Advisory Committee forms
2007	Falls Lake field study completed
2008	Falls Lake named to federal 303(d) list as impaired for chlorophyll *a* and turbidity.
2009	Session Law 2009-486 directs the Commission to adopt a nutrient strategy for Falls Lake by January 15, 2011.
2009	Nutrient Scientific Advisory Board created through Session Law 2009-216
2009	Falls Lake model complete
2010	Falls Lake nutrient strategy is adopted
2011	Stage I of Falls Lake nutrient strategy is initiated
2011	Watershed Oversight Committee appointed to guide oversight of Falls Agriculture Rule.
2016	Falls Lake Nutrient Strategy Interim Report and every 5 years thereafter
2016	Planned attainment of chlorophyll *a* standards downstream of NC-98
2021	Planned attainment of chlorophyll *a* standards in Lower Falls Lake
2021	Stage II implementation begins
2025	Falls Lake Nutrient Strategy Reevaluation report
2026	Planned attainment of chlorophyll *a* standard in Lick Creek
2031	Planned attainment of chlorophyll *a* standard in Ledge and Little Lick Creek
2036	Planned attainment of chlorophyll *a* standard downstream of I-85
2041	Planned attainment of chlorophyll *a* standard throughout Falls Reservoir

FIGURE 3. FALLS LAKE WATERSHED.



Implementation of the Falls Lake Strategy

Falls Lake Nutrient Management Strategy

The Falls Lake strategy is a comprehensive set of rules designed to address excess nutrient inputs to Falls Lake that lead to algae blooms and other water quality problems. The rules require all major sources of nutrients to reduce their nitrogen and phosphorus loads to Falls Lake by 40 and 77 percent, respectively, from a 2006 baseline condition. Modeling has projected that these reductions will achieve water quality standards and all uses of the lake.

The Falls Lake strategy differs from other regional nutrient strategies in several respects. Modeling suggests an unprecedented degree of nutrient reduction, described above, as necessary to restore the lake. Additionally, because the overlapping Neuse strategy was in place for 15 years before the adoption of the Falls Lake strategy, many measures had already been implemented.

To account for these challenges the Falls Lake strategy was designed as a phased, adaptive approach. With the exception of existing development, which is required to offset nutrient loads back to baseline levels, Stage I requires presently achievable controls or obtaining approximately half of the full reduction targets, 20 and 40 percent nitrogen and phosphorus, respectively by regulated sources to meet the chlorophyll *a* standard in the lower lake by 2021. Stage II calls for additional reductions of 40 and 77 percent, respectively, from the upper watershed with the overall goal of achieving all reductions and meeting chlorophyll *a* standards throughout the lake by 2041.

Nutrient sources addressed by the rules include agriculture, fertilizer application, wastewater discharges, and stormwater runoff from both new development and existing developed lands. A trading rule was also enacted, promoting the use of cost-effective management options to meet strategy goals. Table 3 lists the eight rules that make up the Falls Nutrient Strategy.

The adaptive aspect of the Falls Lake strategy allows for continuous evaluation during implementation to inform potential adjustments. The rules allow for supplemental data and modeling to be submitted by affected parties. It also ensures that Stage II is not undertaken without an evaluation of technological and implementation progress and a better understanding of the lake's condition. Parameters for investigation include the lake's response to Stage I implementation, the feasibility and cost of Stage II strategies, and regulatory alternatives for protecting the lake.

The Division is charged to report to the Commission every 5 years regarding strategy implementation, load reductions, and lake response. Furthermore, the Division is tasked with evaluating the state of scientific, technical and accounting advancement across a range of challenging nutrient management issues. This document is the first such report. A reevaluation report is also mandated in 2025 to assess the results of stage I implementation and their implications for stage II.

TABLE 3. FALLS LAKE NUTRIENT STRATEGY RULES.

15A NCAC 02B Rule	Rule Title
.0275	Purpose & Scope
.0276	Definitions
.0277	Stormwater Management for New Development
.0278	Stormwater Management for Existing Development
.0279	Wastewater Discharge Requirements
.0280	Agriculture
.0281	Stormwater Requirements for State & Federal Entities
.0282	Options for Offsetting Nutrient Loads

Strategy Implementation Progress

Wastewater Rule

The Falls wastewater rule aims to reduce point source nutrient loads by establishing (1) annual mass limits on nitrogen and phosphorus for the three existing large wastewater dischargers in the upper watershed and (2) concentration limits for the two smaller private domestic plants in the lower watershed. In the upper watershed, Stage I establishes mass limits based on a 20 percent reduction from baseline in total nitrogen (TN) and 40 percent reduction in total phosphorus (TP), both to be achieved by 2016. Stage II establishes mass limits based on a 40 percent reduction from baseline in TN and 77 percent reduction in TP, both to be achieved by 2036. Limits for the two plants in the lower watershed will also contribute to the point source reduction efforts. As in the Neuse River Basin nutrient strategy, the wastewater rule includes provisions for new and expanding discharges, for a group compliance option, and for in-lieu fee payments to offset exceedance of the annual loading caps. The rule also provides for the transfer of allocation among individual dischargers.

The three major dischargers in the upper watershed are the municipal wastewater treatment plants for South Granville Water & Sewer Authority (SGWASA), North Durham, and Hillsborough. All three have begun optimizing their performance and implementing nutrient controls to meet Stage I allocations by 2016. By 2014 the three facilities collectively reduced their collective nitrogen and phosphorus loads by 20 percent (Figure 4) and 57 percent (Figure 5) respectively from the 2006 baseline.

FIGURE 3. WASTEWATER TN DISCHARGE LOADS, FALLS LAKE WATERSHED.

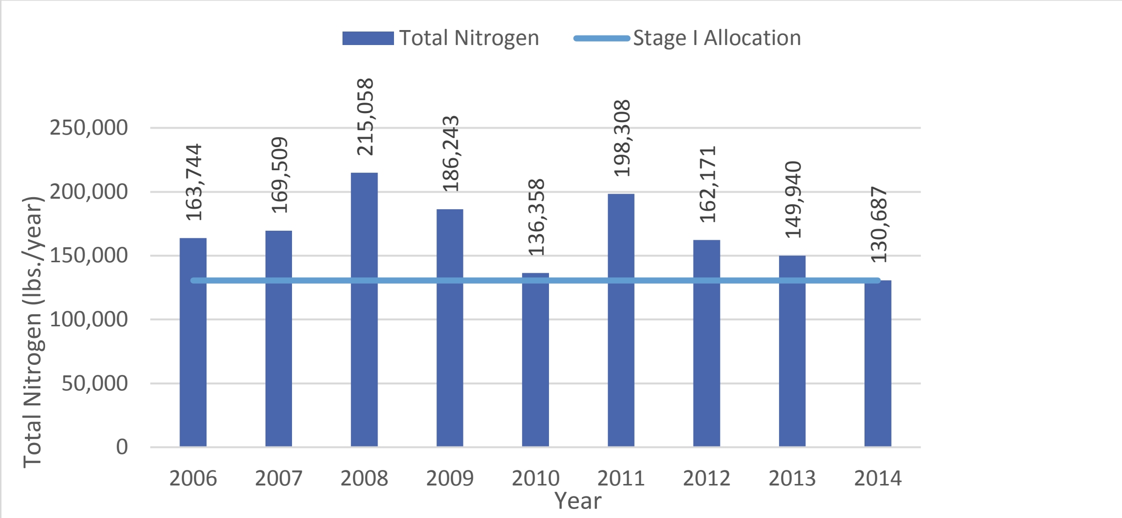
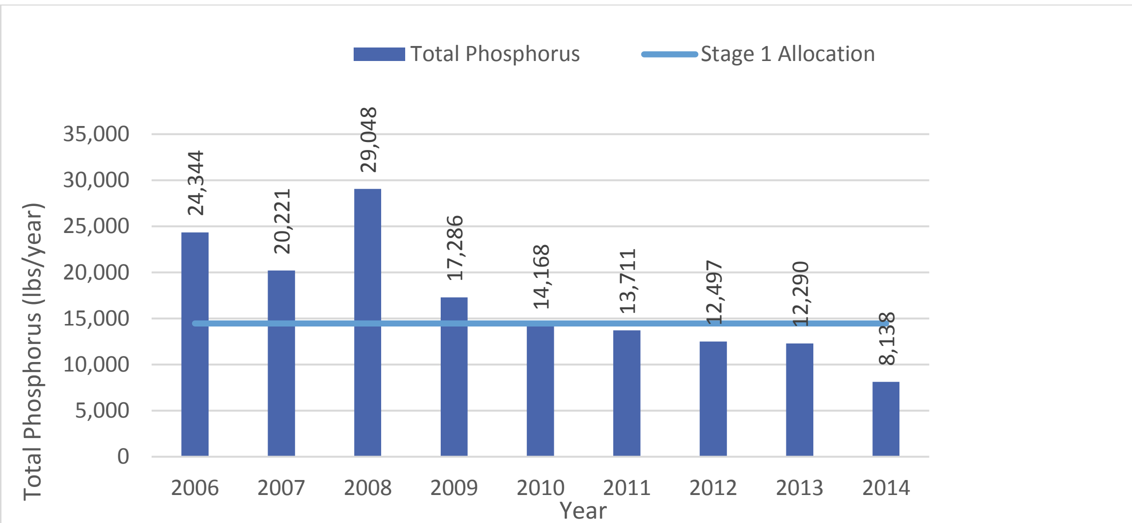


FIGURE 4. WASTEWATER TP DISCHARGE LOADS, FALLS LAKE WATERSHED.



Agriculture Rule

The Agriculture Rule uses a collective strategy for farmers to meet nitrogen loss reduction goals in two stages. The Stage I goal is 20 percent nitrogen loss reduction and 40 percent phosphorus reduction by 2020. Stage II goals are 40 and 77 percent for nitrogen and phosphorus, respectively, by 2035. A Watershed Oversight Committee (WOC) administers the rule, and state and local Soil and Water staff assist farmers with implementation. The WOC developed accounting methods for tracking nitrogen and phosphorus loss, which were approved by the Commission in March 2012. The WOC submitted an initial accounting report to the Commission in March 2013 followed by annual reports in 2014 and 2015.

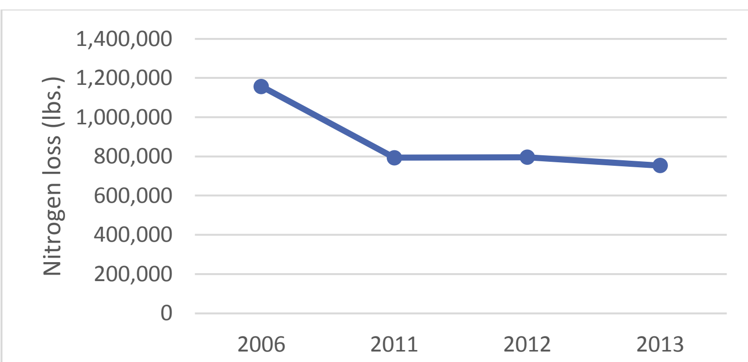
In the 2014 annual report, which covers agriculture activities through 2013, the agriculture sector estimates that they are exceeding the collective nitrogen loss reduction goal with a 35 percent nitrogen reduction in the watershed. Agriculture accounting methods do not estimate changes in phosphorus loss.

Qualitative phosphorus indicators used to infer relative changes in phosphorus loss suggest that phosphorus loss has not increased in the watershed. Phosphorus indicators show a 7 and 4 percent decrease in animal waste phosphorus production and tobacco acreage, respectively, and an increase in cropland conversion to grass and trees since the 2006 baseline, all of which signal decreases in phosphorus loss.

Reductions in nitrogen have been achieved through an overall decrease in cropland acres under production, a decrease in nitrogen application rates, and an increase in best management practices (BMPs) such as 20 and 50-foot riparian buffers. Since the 2006 baseline, cropland decreased in the watershed by an estimated 13,000 acres, 4,400 acres of which were permanently lost to development.

Agriculture is also required to account for pasture-based livestock operations that potentially affect nutrient loading. This is done through the use of a pasture point accounting system that quantifies changes in the extent of livestock-related nutrient controlling BMPs. The point system assigns nitrogen "point" credit values for pasture BMPs in lieu of percent reductions based on recognition that research data are insufficient to provide the level of confidence required for attributing percent reductions in load. For the purposes of the Falls Lake Agriculture Rule, 20 pasture points are required to demonstrate compliance with the Stage I nitrogen reduction goal of 20%.

FIGURE 5. ESTIMATED N LOSS FROM AGRICULTURE, FALLS LAKE WATERSHED.



New Development Rule

This rule requires all local governments in the Falls watershed to develop and implement stormwater programs for new development activities. Under these programs, development projects must be designed to meet nutrient loading rate targets of 2.2 lbs./acre/year TN and 0.33 lbs./acre/year TP. These targets represent the strategy percentage goals applied to average undeveloped loading conditions. Developers are required to achieve between 30% and 50% of the needed reduction onsite, depending on whether they disturb less than or more than one acre for their project. They can then meet the remaining reduction needs through offsite measures including payment of in-lieu fees to the Division of Mitigation Services or purchase of reduction credits from private banks.

All local governments in the Falls watershed adopted and began implementing local stormwater programs in July 2012. Reports documenting their development activity and load reductions are submitted to the Division annually. As of June of 2015 there have been 50,766 lbs. of nitrogen and 3,645 lbs. of phosphorus nutrient offsets purchased by new development projects. In addition, new development projects are also required to meet a portion of their nutrient load reduction requirements onsite.

Existing Development Rule

All local governments in the watershed were required to reduce loading from existing developed lands to 2006 baseline levels by calendar year 2020. Stage II load reduction plans are required in 2021 from local governments in the upper watershed. Stage II load reduction programs will include compliance timeframes proposed by the local government and must lay out implementation plans and pace toward compliance. Local governments are required to submit revised plans for Commission approval every five years.

The Division developed a model program to assist local governments with developing their programs. This model program was presented to the Commission in July 2013, at which time the Division requested more time to work with affected parties to develop credit accounting for additional BMP measures. As a result of this shifted timeline, the Division is proposing to extend the Stage I deadline for existing development reductions to 2024 through the ongoing rules readoption process.

As detailed in the Stormwater Practices section of this report, the Division and the UNRBA are currently working together to establish nutrient reduction credit for additional practices and programmatic measures. These extra tools are being designed to help local governments achieve loading reductions in the most cost effective manner possible. The Division plans to bring a final model program with these additional creditable measures to the Commission within the next two years for approval.

State & Federal Rule

This rule establishes stormwater requirements for state and federal entities analogous to local government new and existing development stormwater rules. The N.C. Department of Transportation (NCDOT) is treated differently than other state/federal entities based on the unique character of its activities. NCDOT began implementing their Commission approved stormwater plan addressing new and existing development in January 2014. New NCDOT road projects are deemed compliant if they meet buffer protection rule requirements. NCDOT identified 6 interchanges in the Lower Falls Lake watershed and 23 interchanges in the Upper watershed for detailed feasibility assessment. Initially, NCDOT selected a location in the Lower watershed, at the intersection of N.C. Highway 50 and NC Highway 98. NCDOT has constructed 11 stormwater retrofits at this location. The intersection consists of approximately 47 acres of NCDOT property including roadways, open space, and forested areas. These retrofits, which involved converting concrete-lined ditches to swales and vegetated areas with enhanced bio-filtration as well as construction of dry detention basins, treat 25 acres and were completed in 2015. A summary of these retrofits and associated nutrient load reductions were included in NCDOT’s November 2015 annual report to the Division.

Non-NCDOT state and federal entities are required to implement their stormwater requirements on the same timeline as local governments. There are a limited number of state-owned properties in the Falls watershed. No non-NCDOT state or federal new development projects have been reported since the rules were adopted.

Lake and Watershed Trends

Changes in Loading to the Lake

At the outset of Falls strategy implementation, the Division initiated an annual lake monitoring plan to allow tracking of nutrient loads as well as the status of standards attainment. For this report, the Division interpreted new and old monitoring data to produce annual nutrient load estimates from 2006 to 2014 from the upper five major tributaries to Falls Lake. The upper five major tributaries are the Eno, Little, and Flat Rivers, and Knap of Reeds and Ellerbe Creeks.

Load Estimation Process

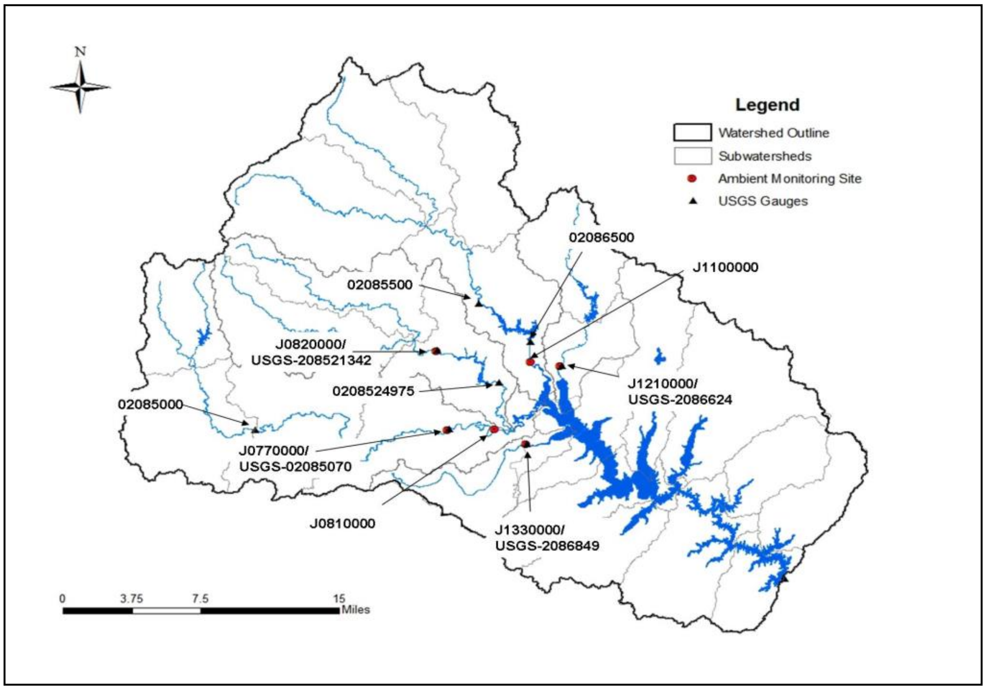
To estimate loads, Division staff utilized flow data from five United States Geological Survey (USGS) gage stations and water quality data from four Division ambient monitoring stations. This method is the same used in the lake model underpinning the Falls rules (Division of Water Quality Modeling/TMDL Unit, 2009a). Table 4 lists stations used for nutrient load calculations. Station locations are shown in Figure 6.

Daily flows at the mouth of each tributary were estimated. Because USGS flow-gauging stations are necessarily located a distance upstream of their mouths, flow at the mouth of a tributary is estimated by multiplying observed daily flow at the gaging station by a drainage area ratio. The streamflows for Knap of Reeds Creek, Flat River, and Ellerbe Creek were used in the Falls Lake Model individually and the flows from the Eno River and Little River were combined because they discharge into the same model cell. Daily nutrient concentrations at the mouth of each tributary were estimated by linear interpolation between two consecutive measurements at the four Division ambient monitoring stations. Because three of these streams include a wastewater treatment plant discharge, there is additional uncertainty associated with applying a drainage area ratio to the flows and instream concentrations observed downstream of a wastewater plant

Table 4. USGS Gage Stations and Division Ambient Monitoring Stations.

Tributary	USGS gage station	Ambient monitoring station
Knap of Reeds	USGS 02086624	J1210000
Flat River	USGS 02086500	J110000
Little River Eno River	USGS 0208524975 USGS 02085070	J0810000
Ellerbe Creek	USGS 02086849	J1330000

FIGURE 6. LOCATIONS OF USGS GAGE STATIONS AND DIVISION AMBIENT MONITORING STATIONS IN THE FALLS LAKE WATERSHED.



Once the average daily streamflows and daily concentrations were estimated, the nutrient load was calculated by multiplying the flow by the corresponding concentration for each day.

Loading Results

Table 5 provides the resulting annual nutrient load contributions from the upper five major tributaries to Falls Lake from 2006 to 2014. Annual load estimates are not available from 2009 to 2012 as budget constraints resulted in an insufficient number of sampling events to allow load estimation. At least nine water samples are needed to represent data variability and seasonal differences when estimating annual loads.

TABLE 5. ESTIMATED NUTRIENT LOAD CONTRIBUTIONS FROM THE FIVE MAJOR TRIBUTARIES TO FALLS LAKE.

Combined Nutrient Load from the Five Major Tributaries	Nutrient Load		Combined Average Flow from the Five Major Tributaries (cfs)*
	Phosphorus (lbs./year)	Nitrogen (lbs./year)	
2006	107,915	819,854	289.9
2007	82,283	691,397	241.4
2008	104,612	935,335	301.8
2013	56,223	925,732	422.3
2014	48,413	991,186	463.5

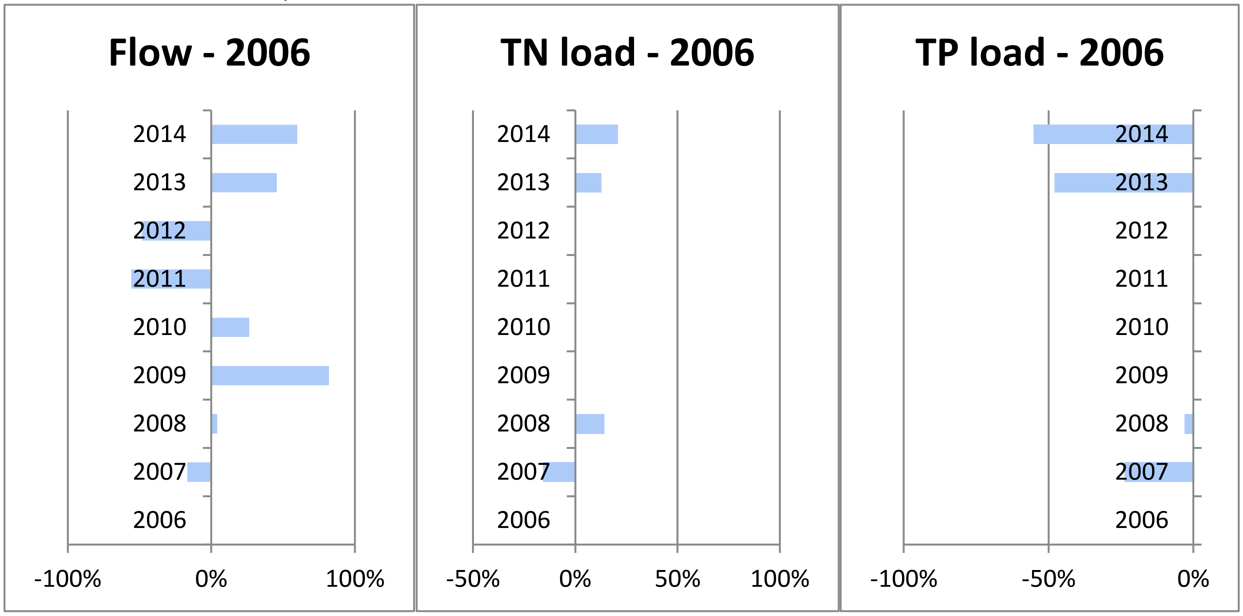
* Calculated as the sum of annual averages of the daily mean flow from the five major tributaries.

TABLE 6. NUMBER OF SAMPLES COLLECTED EACH YEAR FOR NUTRIENT MEASUREMENTS.

Year	Station			
	J0810000	J1100000	J1210000	J1330000
2006	12	26	26	26
2007	10	19	19	19
2008	10	10	10	10
2009	8	8	8	8
2010	4	4	4	4
2011	4	4	4	4
2012	8	8	8	8
2013	12	12	12	12
2014	11	11	11	11

The graphs in Figure 7 show the estimated flow, total nitrogen and total phosphorus load differences from the baseline year of 2006 expressed as percent of 2006. In addition to nutrient yield from both point sources and nonpoint sources in the drainage basin, nutrient loads and lake responses to the load are also often impacted by hydrological conditions. Higher flow tends to be associated with higher nutrient loads to the lake and more discharge downstream from the dam when lake levels are high. This scenario then leads to shorter residence time in the lake and less time for algal growth to occur. When higher flows and nutrients loads enter the lake when water levels are low, the lake acts more as a storage basin and the residence time, and subsequently algal growth, can be relatively high. Therefore, depending on the preceding hydrologic conditions, higher flows and nutrient loads can either enhance or impede algal growth in the lake. The variation of annual nutrient loads is presented together with the flow (Figure 8) so that hydrological conditions can be taken into consideration when interpreting the results. DWR expects to have enough data available for the next 5-year report to perform more advanced loading analyses to highlight changes in lake loading due to hydrological impact versus changes due to strategy implementation.

FIGURE 7. ESTIMATED FLOW, TOTAL NITROGEN AND TOTAL PHOSPHORUS LOAD AS PERCENT OF 2006.



The results of this loading analysis indicate that annual delivered total nitrogen load from the upper five subwatersheds has increased by approximately 20 percent since the 2006 baseline. They also show that annual delivered total phosphorus loads have decreased 55 percent over the same time period. The increases in nitrogen correlate with wet years, suggesting that the increased precipitation resulted in additional nonpoint source runoff nutrient input. The reductions in phosphorus loading to the lake and subsequent water quality improvements are largely attributable to reductions by the three major municipal wastewater treatment plants located in the upper Falls watershed. Reductions from agriculture and new development may have also supported these trends to some degree. Additional details on reductions by source are provided in the rule implementation section of this report.

Lake Improvement

In addition to evaluating changes in nutrient loading, the Division conducted an assessment of changes in chlorophyll *a* data in Falls Lake before and after the strategy became effective in January 2011. The following is a summary of the percent exceedance of the chlorophyll *a* standard (40 ug/L) pre and post strategy implementation.

Two chlorophyll *a* datasets were included in the percent exceedance analysis. The first is for the time period of 2005-2007, prior to adoption of the strategy. The second is for the time period of 2011-2014, during which many of the strategy components were implemented. Figures 9 and 10 compare the chlorophyll *a* standard percent exceedance rates for the two time periods. Table 7 summarizes the results by station. Due to budget limitations Falls lake was not monitored from October 2007 through 2010. Since that time, the Division has conducted monthly sampling of the lake.

FIGURE 8. PERCENT OF DATA EXCEEDING CHLOROPHYLL *A* STANDARD OF 40 µG/L FROM 2005 – 2007.

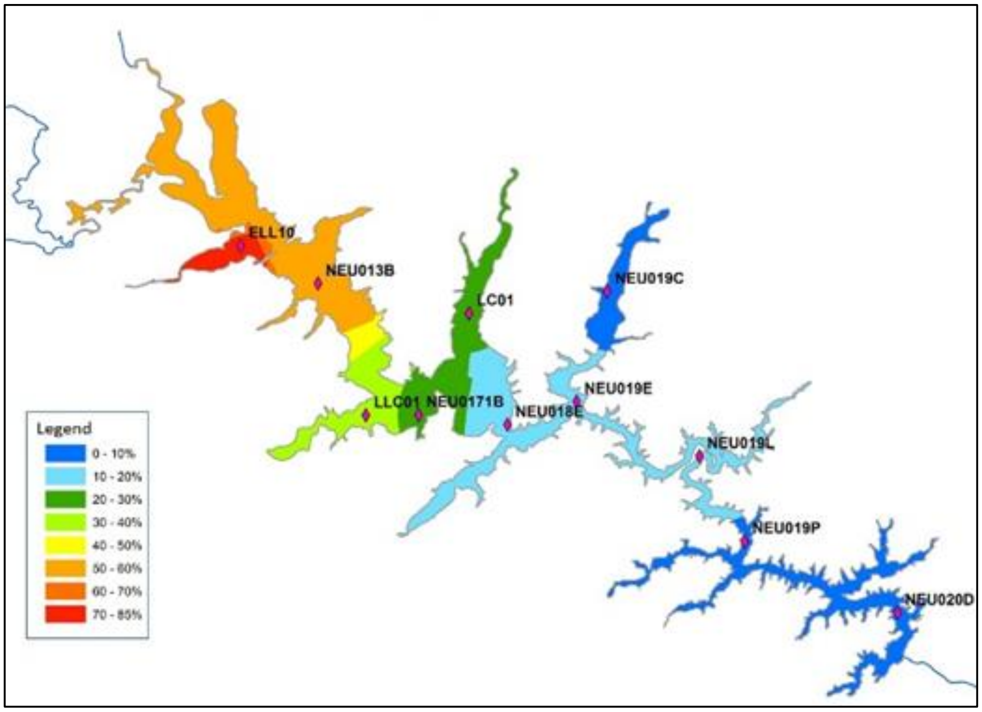


FIGURE 9. PERCENT OF DATA EXCEEDING CHLOROPHYLL *A* STANDARD OF 40 µG/L FROM 2011 – 2014.

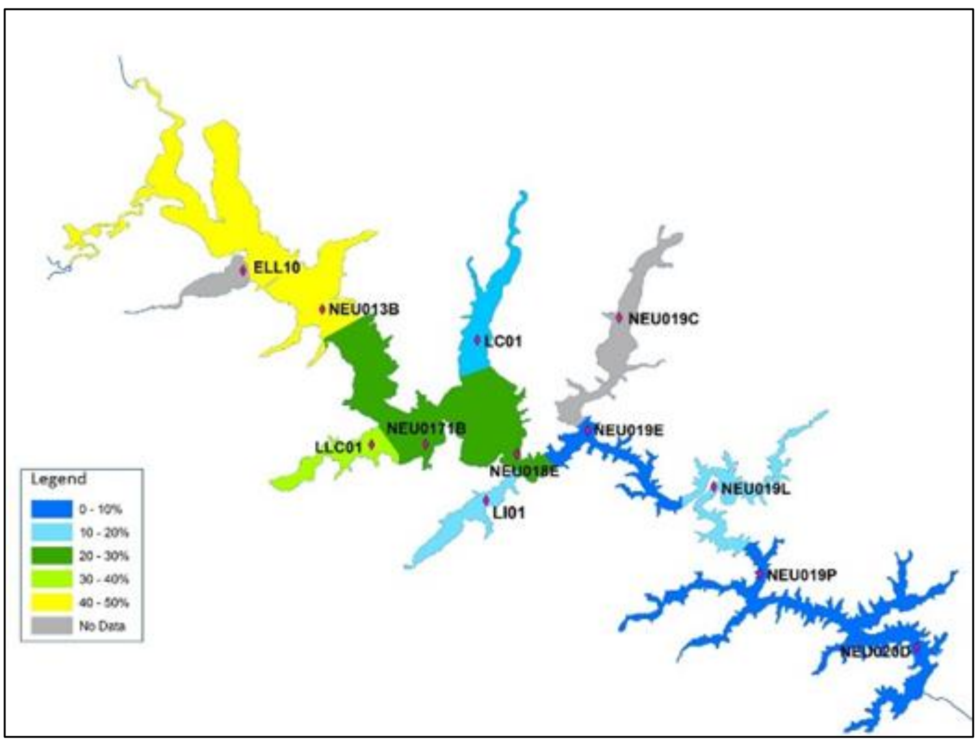


TABLE 7. COMPARISON OF PERCENT EXCEEDANCES OF THE CHLOROPHYLL A STANDARD OF 40 µG/L.

Station	2005-2007		Post-Strategy Start 2011-2014	
	n	Percent over 40 µg/L	n	Percent over 40 µg/L
Mainstem				
NEU013B	50	53%	47	45%
NEU0171B	51	25%	47	28%
NEU018E	51	16%	47	21%
NEU019C	51	4%	not sampled	
NEU019E	51	16%	48	8%
NEU019L	51	12%	48	10%
NEU019P	51	10%	47	6%
NEU020D	51	10%	46	4%
Arms				
ELL10	38	84%	not sampled	
LC01	38	21%	46	17%
LLC01	38	39%	46	33%
LI01	0	n/a	44	14%

This analysis of water quality data collected at the ten in-lake monitoring stations sampled monthly by the Division shows that percent exceedance of the chlorophyll *a* standard has improved in the lower lake since 2011. Modest improvements have been achieved in the upper lake as well.

303(d) Assessment Summary

The Division performs water quality monitoring in Falls Lake and performs periodic 303(d) use support assessments to judge progress on and compliance with meeting the strategy goal of achieving the chlorophyll *a* water quality standard throughout the lake. The Falls rules provide that when a previously impaired segment of the lake demonstrates compliance with the state's the chlorophyll *a* water quality standard for at least two consecutive use-support assessments, further load reductions will not be required.

For the 2008, 2010, and 2012 303(d) lists, the assessment methodology allowed for a 10 percent exceedance rate. The results of these three assessments indicated chlorophyll *a* impairment for both the upper and lower segments of Falls Lake.

For the 2014 use support assessment, the State's assessment methodology changed to allow for a 10 percent exceedance with 90 percent confidence. The 2014 use-support assessment showed the lower lake meeting the chlorophyll *a* standard.

The Division is in the process of analyzing data and finalizing the assessment for the 2016 303(d) list. The list is due to the Environmental Protection Agency on April 1, 2016. The Division will notify affected parties at that time should results show the lower lake is meeting the chlorophyll *a* standard for a second consecutive assessment cycle. Table 8 below summarizes the changes in 303(d) listings signifying impaired waters since the lake's initial impairment listing in 2008.

TABLE 8. CHANGES IN IMPAIRED WATERS FROM 303(D) ASSESSMENTS SINCE 2008.

Assessment Unit ID	Description	Parameter (Impairment)
2008 303(d) list		
27-(1)	From source (confluence of Eno River Arm of Falls Lake and Flat River Arm of Falls Lake) to I-85 bridge	turbidity, chlorophyll *a*
27-(5.5)	From I-85 bridge to Falls Dam	chlorophyll *a*
2010 303(d) list		
27-(1)	From source (confluence of Eno River Arm of Falls Lake and Flat River Arm of Falls Lake) to I-85 bridge	turbidity, chlorophyll *a*
27-(5.5)a	From I-85 bridge to Panther Creek	turbidity, chlorophyll *a*
27-(5.5)b	From Panther Creek to Falls Dam	chlorophyll *a*
2012 303(d) list		
27-(1)	From source (confluence of Eno River Arm of Falls Lake and Flat River Arm of Falls Lake) to I-85 bridge	turbidity, chlorophyll *a*[1]
27-(5.5)a	From I-85 bridge to Panther Creek	turbidity, chlorophyll *a*[1]
27-(5.5)b	From Panther Creek to Falls Dam	chlorophyll *a*[1]
2014 303(d) list		
27-(1)	From source (confluence of Eno River Arm of Falls Lake and Flat River Arm of Falls Lake) to I-85 bridge	turbidity, chlorophyll *a*[1]
27-(5.5)a	From I-85 bridge to Panther Creek	turbidity, chlorophyll *a*[1]
27-(5.5)b1	From Panther Creek to Ledge Creek Arm	chlorophyll *a*[1]
27-(5.5)b2	Ledge Creek Arm	No nutrient related impairments
27-(5.5)b3	From Ledge Creek Arm to Lick Creek Arm	chlorophyll *a*[2]
27-(5.5)b4	From Lick Creek Arm to Falls Dam	No nutrient related impairments

[1] Chlorophyll *a* in category 4b because the Nutrient Management Strategy was in place.
[2] This assessment is in category 3b1, which is assigned when greater than or equal to 10% of samples exceed criteria with <u>less</u> than 90% confidence, and there is a management strategy (not a TMDL) in place for that parameter. The management strategy remains in place to ensure that criteria are ultimately attained.

Upper Neuse River Basin Association Monitoring

In addition to the Division's in-lake and ambient watershed water quality monitoring, the UNRBA and member local governments have begun their own supplemental monitoring of the watershed. This monitoring is being done primarily to address the uncertainty associated with the original watershed and lake modeling conducted by DWR and to support the UNRBA's reexamination of the regulatory framework for

Stage II of the rules. It will also provide additional valuable water quality data that can be used by the Division in future assessments of the lake and tributaries throughout the watershed as well as inform future management decisions.

At the time the original Falls Lake modeling effort was conducted, the data available to develop and calibrate the models was limited, and DEQ did not have the resources or the time to conduct studies that would address key data gaps. The strategy acknowledges the high degree of uncertainty associated with the modeling and allows for a reexamination process. The UNRBA is currently investing $800,000 per year to conduct monitoring studies that will reduce the uncertainty associated with the modeling that was used to develop the Falls Lake strategy. The UNRBA Monitoring Program has two major components: 1) the Routine Monitoring of tributaries at fixed stations, and 2) Special Studies which focus sampling efforts for the purpose of answering specific questions. All components of the UNRBA Monitoring Program were specifically designed to build upon the scientific assessment and modeling predictions used by the state to support the Falls Lake Nutrient Management Strategy. Elements of the program are summarized below; additional information about the UNRBA monitoring program, including a recently released annual report, are available online at http://www.unrba.org/monitoring-program:

- The UNRBA Routine Monitoring Program measures nutrients, sediment, carbon, and chlorophyll a on streams in the Falls Lake Watershed. This program provides data on parameters and locations which were not available when the Falls Lake Nutrient Management Strategy was developed.

    - Lake Loading Stations: Eighteen stations are located on the major tributaries to Falls Lake near where they enter the lake (Figure 11). Monitoring at these stations provides data to characterize tributary inputs to Falls Lake. The five largest tributaries that enter the upper end of the lake are monitored twice-monthly; the remaining 13 stations are monitored once per month.

    - Jurisdictional Stations: An additional 20 monitoring stations are located further upstream on these tributaries (Figure 11). Data from these stations can be used to characterize water quality near boundaries between jurisdictions. Each of these stations is monitored monthly.

    - Falls Lake Monitoring: Monitoring in Falls Lake is primarily conducted monthly by DWR. In addition to the parameters analyzed by DWR, the UNRBA conducts analyses which can be used to further characterize the carbon content of the water.

- In addition, several special studies are also being conducted by the UNRBA to address specific questions:

    - High Flow Monitoring: This monitoring occurs on a subset of the routine tributary stations at times when flow is elevated due to rainfall. All parameters associated with routine monitoring are also measured during high flow events. This supplemental effort helps to ensure that data are available for locations expected to reflect substantially different pollutant loading patterns during periods of high flows such as stagnant wetland areas.

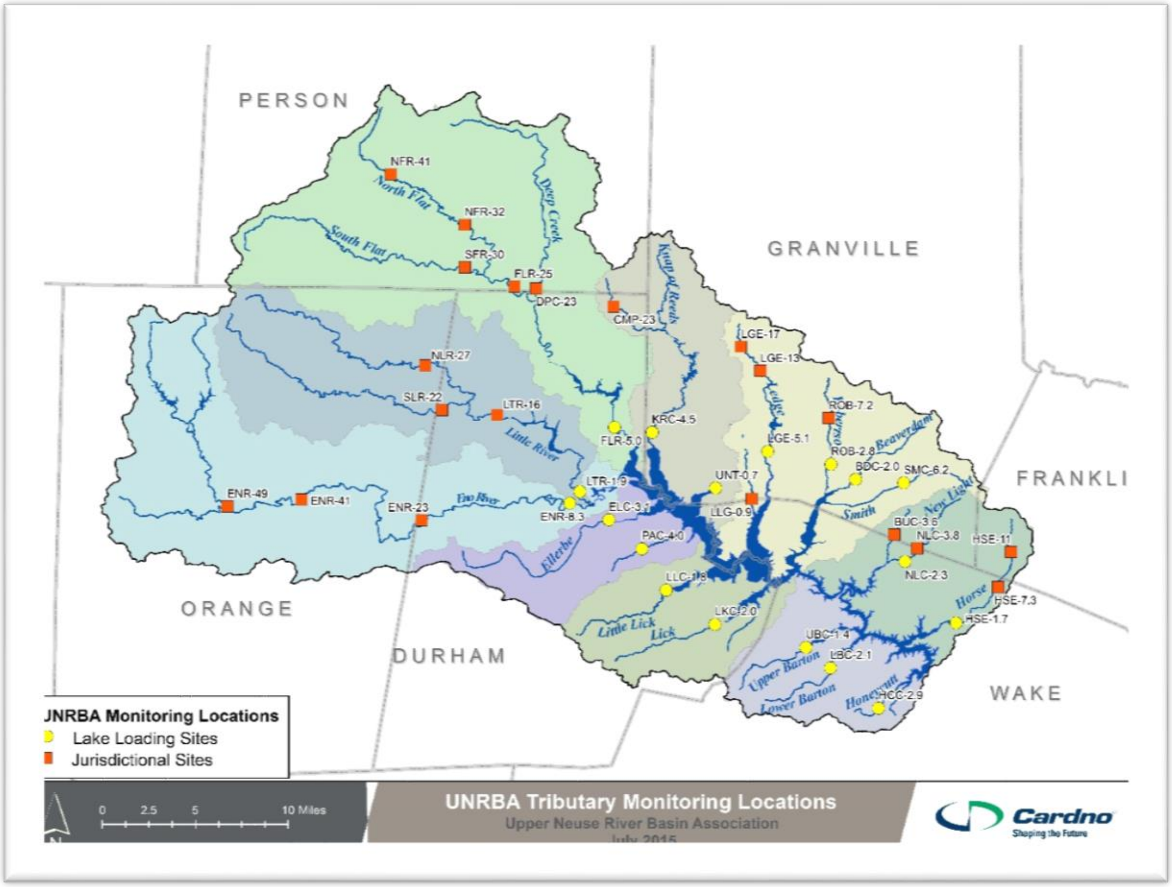
    - Storm Event Sampling: Measures nutrients and carbon on a sub-daily time scale to characterize how water quality changes throughout the elevated flow period associated with storms and how storm events affect tributary contributions of nutrients and related parameters. Storm Event sampling occurs two to four times per year on two tributaries. These data provides information to help to improve loading estimates that drive the Falls Lake algal response model.

- Falls Lake Sediment Sampling: Was conducted at approximately 20 locations throughout Falls Lake to evaluate nutrient concentrations in lake sediments and to improve estimates of internal loading of nutrients from the lake sediments.

- Falls Lake Constriction Point Sampling: Measures the flow and the movement of nutrients, sediment, carbon, and chlorophyll a from one segment of Falls Lake to the next over a range of flow conditions at specified bridge causeways (I-85, Fish Dam Road, and Highway 50). This study provides data to aid model calibration and to characterize how the lake's shape and the presence of bridge causeways affects the flow and processing of nutrients in different parts of the lake.

The UNRBA monitoring programs described above are designed to support three primary goals: revise the lake response modeling, support the development of alternate regulatory options as needed, and more precisely allocate loads to sources and jurisdictions. In July 2014, the Division approved the UNRBA's quality assurance project plan and monitoring began in August 2014. The first annual report will be submitted April 2016, summarizing data collected through 2015. The Division anticipates using the data collected from the UNRBAs routine and jurisdictional monitoring program in addition to the data already collected by the Division in the next status report in 2021.

FIGURE 10. UNRBA LAKE LOADING AND JURISDICTIONAL MONITORING LOCATIONS.



More information about the UBRBA's monitoring program can be found on the organization's website at http://www.unrba.org/monitoring-program.

State of Knowledge

In addition to lake loading progress, 5-year Falls reports are to address advances in various nutrient management disciplines, technologies and accounting processes pertinent to the Falls Lake strategy. The results of staff's inquiries are provided below. For orientation purposes, at the start of each topic, excerpts of the guiding rule text are provided; the entire segment of the Purpose and Scope rule establishing the scope of the report is provided in Appendix I.

Wastewater Requirements and Steps Taken

"The Division…shall address… the state of wastewater…nitrogen and phosphorus control technology…"

This section provides a summary of the technology employed by each of the three major wastewater treatment plants in the upper Falls watershed to meet their Stage I allocations by 2016. It also provides an overview of new technologies and waste management options they may need to explore in order to meet Stage II allocations by 2036, and the current outlook for those options.

Stage I mass limits for the Upper Falls dischargers are equivalent on average to 3.09 mg/L TN and 0.34 mg/L TP at 110 percent of current flows (an allowance selected for 2016 flows). These limits should be initially achievable using biological nutrient removal technology. The Stage 2 mass limits, on the other hand, are the most stringent the Division has ever proposed, equivalent to approximately 1.1 mg/L TN and 0.06 mg/L TP at the facilities' full permitted flows. At full flow, these limits are beyond the reach of economically achievable biological nutrient treatment technology.

For the sake of comparison, treatment levels for best available technology (BAT) are commonly cited as 3.0-3.5 mg/L TN and 0.05-0.5 mg/L TP in southern climates. Thus, Falls Lake dischargers using current treatment technologies would not meet the Stage 2 mass limits for nitrogen, at least not when the facilities reach their full permitted flows (mass = flow x concentration). However, it is still reasonable to expect that, with more experience in the operation of nutrient treatment processes and with further improvements in treatment technologies, performance will move closer to the Stage 2 limits. In fact, we have already seen progress in the five years since the strategy was first adopted:

- Several facilities in the lower Neuse River basin have achieved an annual average TN less than 2.0 mg/L in recent years,
- Operations-based approaches are achieving significant reductions and forestalling major upgrades across the country, and
- At least one promising new technology (the anammox process) has emerged and will soon be employed at the Durham – South WWTP.

It remains to be seen what advances can be realized in the coming 20 years. The Division will continue to monitor these developments and provide an update in the next report.

Before the Falls Lake rules went into effect in 2011, dischargers in the upper Falls watershed were already subject to nitrogen limits under the existing Neuse nutrient strategy that, at permitted flows, require moderate biological nutrient removal (5.5 mg/L TN at full permitted flows). Each of the facilities also had in place a land application program to dispose of wastewater residuals and biosolids. Chemical addition and gravity settling have been used to remove phosphorus.

Since the Falls rules went into effect, each of the upper Falls facilities has taken significant steps towards achieving their Stage I allocations through a combination of optimized system management and treatment technology upgrades.

Current Wastewater Treatment Technology

Nitrogen removal technology for municipal wastewater discharges has existed for decades but was used only rarely until the mid-1990s. Performance continues to improve as the technology evolves and operators and consultants become more experienced with the new systems. The accepted limits of biological nutrient removal technology have decreased from 6-8 mg/L TN in the late 1980s and early 1990s to 3.5 mg/L in the late 1990s, then to 3.0 mg/L in the last decade. Today it appears that 2.0 mg/L or less total nitrogen is potentially attainable, about a third as much as considered attainable less than 20 years ago (DWR, 2010).

The following is a brief summary of recent upgrades and current treatment technologies used at each facility in the upper watershed.

North Durham Water Reclamation Facility (WRF)

The North Durham WRF has a permitted capacity of 20 million gallons per day (MGD) and discharges into Ellerbe Creek. A master plan for future phased expansion and attainment of more stringent effluent standards was completed in 2012. This planning effort covers the next 20 years of operation and addresses a number of improvements to meet the Falls wastewater rule requirements. It includes plant upgrades estimated to cost in excess of $13 million dollars. The facility currently uses a 12.5 MGD flow train, including flow equalization, a 5-stage biological phosphorus-nitrogen removal activated sludge process, deep-bed effluent filters and a supplemental carbon and alum feed building. The 5-stage biological nutrient removal flow train was designed and constructed in 2009. Ongoing optimization of existing processes has reduced nitrogen discharges to meet 2016 permit requirements. A supplemental carbon and alum feed building was completed in 2014, resulting in significant decreases in phosphorus discharge. A bulk water reuse station is scheduled to be online by the end of 2015.

South Granville Sewer & Water Authority (SGWASA)

The 5.5 MGD South Granville Water and Sewer Authority treatment plant currently uses a Virginia Initiative Plant treatment process which uses anaerobic, anoxic and oxidation basins for biological phosphorus removal and denitrification and nitrification. A detailed operational assessment was completed in 2009, resulting in optimization of total nitrogen removal performance. With no new technology, the plant has reduced its average effluent total nitrogen concentration significantly from 12 mg/L in 2008 to 4 mg/L in 2010. Phosphorus discharge concentrations are approximately 1 mg/L.

SGWASA is currently in the process of a $30 million upgrade to improve overall system performance to fully meet Stage 1 discharge requirements. Due to contractor delays, these additional improvements aren’t expected to be online until late 2016. These upgrades will include conversion of the existing treatment process into a 5-stage Bardenpho process with denitrification filters, new chemical feed systems, and utilization of dewatering and land application as a preferred biosolids management alternative. Improvements scheduled for completion in late 2016 will further reduce average effluent total nitrogen concentration to 2.5 mg/L.

Hillsborough Wastewater Treatment Plant

The Hillsborough treatment plant has the capacity to treat up to 3 MGD and is currently operating at slightly under half capacity. A $19 million expansion and upgrade of the plant was completed in 2014. The facility's 2 stage activated sludge treatment process was upgraded to a 5-stage biological nutrient removal process which included installation of new denitrification filters, disinfection, dechlorination, and solids processing. Treated water is discharged to the Eno River. Stabilized waste solids are reused as a soil amendment/fertilizer on several neighboring agricultural fields or transported to a composting facility. TN loading was reduced by 64 percent between 2013 and 2014 with average nitrogen discharge concentrations ranging between 1.5 to 1.8 mg/L.

Advanced & Improved Wastewater Treatment Technology Options

Depending on how quickly their flows increase, the upper Falls facilities may have to apply more advanced treatment technologies to meet their Stage I nutrient limits. They will certainly have to do so to meet their final Stage II limits. The upper Falls dischargers currently rely on conventional biological nutrient removal processes to remove as much nitrogen as possible and more advanced technologies to achieve further reductions. All three of the upper Falls dischargers have evaluated available technologies and concluded that presently reverse osmosis systems are the most likely approach to effectively meet the proposed nutrient limits.

Reverse Osmosis

Reverse osmosis or ion exchange may be able to reduce nitrogen concentrations to 1 mg/L or lower. Reverse osmosis systems work by concentrating pollutants and other materials found in wastewater, separating it into a high-quality effluent stream (approximately 75 percent of the total flow) and a 'reject' stream (25 percent). Cost estimates for reverse osmosis units vary based on the amount of reject water produced. Even when used in series, this form of treatment could result in a total volume of reject water that exceeds 500,000 gallons per day. There is considerable uncertainty about how to properly manage this reject stream, which casts doubt on the feasibility of relying entirely on reverse osmosis for nutrient removal.

Reverse osmosis systems are rarely used to treat municipal wastewater on this scale, thus experience is limited and actual performance and true costs are uncertain. Also, impacts on the rest of the plant's operations are uncertain. Questions remain regarding how the reverse osmosis process will affect solids handling and disposal, side-stream management, and general operations.

Capital costs for reverse osmosis are high, perhaps $16-18 per gallon of treatment capacity compared to $1-3 per gallon for biological nutrient removal upgrades. These high costs result in part because extensive pretreatment such as membrane filtration is necessary to maximize the service life of the reverse osmosis units. Membrane filtration and reverse osmosis units are also energy-intensive, so their operating costs are high and potentially volatile as well.

Wastewater Reuse

Wastewater reuse programs can also be an effective means of reducing nutrient loads. In reuse, a portion of the treated effluent is diverted from discharge and either applied to land or reclaimed for beneficial uses like irrigation, cooling water supply, or process uses. Opportunities for land application or irrigation in the Falls watershed are limited due to unfavorable soil conditions and topography. Suitable sites also tend to be relatively small and fragmented, making it more difficult and expensive to establish distribution lines to those sites.

Source Controls

Source controls refers to the process of reducing nutrient contributions at the sources. Where dischargers to the municipal system are industries with significant nutrient levels, this can be an effective means of reducing a treatment plant's nutrient discharge. This approach has limited utility in the Falls watershed, as none of the municipal plants has industrial users that are major nutrient sources.

Other Emerging Wastewater Treatment Technologies

In March 2013 the EPA published *"Emerging Technologies for Wastewater Treatment and In-Plant Wet Weather Management,"* which provides an overview of recent innovative and emerging wastewater treatment technologies. One promising treatment technology included in this guidance document is the use of Anammo*x* bacteria in a biological nitrogen removal process. The process can save up to 63 percent of the oxygen demand (energy) compared to conventional nitrification/denitrification. It can achieve up to 95 percent ammonia removal and produces much less biosolids in comparison to existing processes (Tetra Tech, 2013a). Wastewater researchers and designers are still exploring the nature of this new treatment process, the range of applications and conditions for which it well suited, appropriate design and operating parameters, and actual performance in full scale applications. The City of Durham's Anita™ Mox process for side-stream treatment was placed into service at the South Durham Water Reclamation Facility in November 2015. This site, which discharges into the Upper New Hope Arm of Jordan Lake, is the first installation in North Carolina and second in the United States. Currently, the process is meeting removal projections of 60% in both reactors. Based on the results of the pilot process at the South Durham facility, the City of Durham will consider replicating the installation at the North Durham WRF. A further update on its success will be provided in the next status report.

Outlook for Falls Dischargers

While emerging technologies may be available as the Falls strategy enters Stage II, it appears likely that point source dischargers in the upper Falls watershed will ultimately rely on a combination of advanced treatment technology and wastewater reuse to meet their final nutrient limits. While large-scale reuse has not been seen as a cost-effective option in the past, it may become more desirable when compared with far more expensive advanced treatment alternatives.

Presently available technologies are also expected to become more affordable. A 2004 review by the Chesapeake Bay Program noted that nutrient reduction technology is expanding at an exponential rate. 8 mg/L TN was once state-of-the-art for that region and cost about $35 per lb. of TN removed, but by 2004, 3 mg/L was achievable and cost less than $10 per lb. removed. The review also noted that a study of 66 major municipal plants in Maryland concluded that the costs of reaching 3 mg/L TN today would be 32 percent less than estimated in the previous Chesapeake Bay study. When Virginia's Hampton Roads Sanitation District updated the estimates for its eight facilities, the estimates came in 23 percent less than the original estimates. These improvements came within a period of four years from the original cost study.

Given the high cost estimates for advanced treatment at this time, it seems likely that the potential cost of meeting the Stage II nutrient limits may itself spur acquisition of more effective and more affordable processes.

Current and Projected Extent of Reuse & Land Application

"The Division…shall address… use and projected use of wastewater reuse and land application opportunities"

Durham, Hillsborough and SGWASA all have active permits to land apply residual solids originating from their wastewater treatment facilities. Since the 2006 baseline year, land application of these residuals from Durham has shown a variable but mildly declining trend. Since 2013, Hillsborough has discontinued its land application activities in favor of offsite composting for its residuals. SGWASA shows no notable trends in their utilization of land application for residuals.

TABLE 9. LAND APPLICATION OF WWTP RESIDUALS IN FALLS LAKE WATERSHED (DRY TONS).

	2006	2007	2008	2009	2010	2011	2012	2013	2014
SGWASA (Granville Farms)	*	378	235	273	283	308	238	357	339
Hillsborough	281	216	263	238	335	294	228	0	0
Durham	4,532	5,751	4,341	3,845	5,161	3,583	4,070	3,306	4,850
Total WWTP Residuals	4,813	6,345	4,839	4,356	5,779	4,185	4,536	3,663	5,189

Stormwater Treatment Technology

"The Division…shall address…the state of … stormwater nitrogen and phosphorus control technology."

Existing Development requirements are a recent regulatory innovation in North Carolina and nationwide, and to this point rely primarily on relatively costly retrofitting of stormwater BMPs into developed landscapes. To meet this challenge the regulated community desires the broadest set of options supportable for compliance along with best available estimates of cost-effectiveness. To address this need the Division has been working closely with affected parties over the past three years to identify and prioritize additional measures and add to the 'toolbox' of nutrient-reducing measures, and to develop credit methods and associated design conditions. In addition, the UNRBA has taken the initiative, working with the Division, to further expand the toolbox through development of credit methods and design standards for additional nutrient measures. This section summarizes the ongoing work to develop nutrient credit for additional measures and provides an update on the status of these efforts.

The Division is currently developing nutrient credit for a number of measures, and the Department has granted funds to the UNRBA to add to monies pooled by its member governments for an association contract to establish credit for an additional set of measures. Through this joint effort, credit is being established for additional technologies across all source types including agriculture, wastewater, ecosystem restoration and urban stormwater. Draft credit guidance documents are being reviewed by the legislatively established Nutrient Scientific Advisory Board, or NSAB, which includes Jordan and Falls local government stormwater professionals, to improve their utility. This collaborative effort is proving key to successful implementation of the existing development requirements by local governments.

In 2012, the Division began working with the NSAB to identify and prioritize alternative, potentially creditable nutrient practices, and in 2013 utilized 205(j) grant funds for Tetra Tech to conduct a synthesis of the science characterizing the nutrient load reduction performance of six priority nutrient measures identified by the board. The Division has since used that product as a basis for developing practice crediting and design specifications for these measures. Staff is now collaborating with practice-specific technical experts including Chesapeake Bay expert panelists, DEMLR stormwater permitting staff, Division stream and buffer permitting staff, and DEH onsite wastewater staff, to develop guidance documents, with review by the NSAB.

Separately in 2013, the UNRBA used member government contributions and assistance from the Department to contract with Cardno and the Center for Watershed Protection (the Center) to develop nutrient crediting for an additional ten priority measures. Cardno and the Center worked with NSAB members, UNRBA member governments, technical experts and other stakeholders during 2014 to rank the implementation potential of an initial list of 48 candidate nutrient measures. During winter 2014, the group prioritized 10 measures for full credit development and five others for future development pending funding. Cardno and the Center are currently developing credit methods and design specifications for the highest priority practices. They expect to complete the 10 practices by spring 2016. The Division intends to finalize credit standards for their measures and those being developed by UNRBA during 2016. These new practice standards, in addition to the practices already available in the department's Stormwater BMP Manual will be included in a final Existing Development Model Program in late 2016 or 2017 for EMC approval.

Establishing nutrient credit for these additional practices will greatly improve the options available to local governments and are important additions to the toolbox of available measures as they seek to cost-effectively meet existing development nutrient reduction goals. Table 10 provides the status of the existing development practice toolkit.

TABLE 10. NUTRIENT PRACTICES AVAILABLE OR UNDER DEVELOPMENT.

Source Type	Practice	Relative Cost per Unit Reduction[1]	Development Status (% Complete)
Agricultural/ Rural	Riparian buffer restoration	$	25
	Livestock exclusion	$	75
	Cropland conversion to trees or grass	$$	0
Ecosystem Restoration	Stream restoration/enhancement[5]	$$$$	75
	Riparian buffer restoration - urban	$$	25
	Land or forest protection	$$$	50
	Regenerative stormwater conveyance	$$	10
Local Government	Improved street sweeping / Leaf Litter[5]	$$	80
	Increased urban canopy cover	$$	0
	Illicit Discharge Detection & Elimination	$	5
Urban Stormwater Retrofits[4]	Level spreader & vegetated filter strip retrofit	$$	100
	Rainwater harvesting (rooftop retrofit)	$	100
	Bioretention retrofit	$$$	100
	Grassed swale retrofit	$$$	100
	Permeable pavement retrofit	$$	100
	Stormwater wetland retrofit[5]	$$	100
	Wet detention basin retrofit[5]	$$	100
	Dry extended detention basin retrofit	$$$$	100
	Sand filter retrofit	$$$$	100
	Green roof	$$$$$	100
	Disconnect impervious surfaces[5]	$	95
	Floating treatment wetlands[5]	$$	90
	Infiltration devices	$$	80
	StormFilter[3]	$$$	75
	Filter strip design variants	$	85
	Bioretention design variants	$$	85
	Soil improvement/urban nutrient management	$$$	80
	Algal turf scrubber[2]	$	25
	Permeable pavement design variants	$$	40
	Grass swale design variants	$$	40
Wastewater	Remedy discharging sand filter[5]	$$	95
	Remedy malfunctioning septic system[5]	$$$	40
	Regionalization (package plant)	$$$	30

Footnotes

[1] Relative Cost Per Pound of N/P removed, $, $$ - Low; $$$ - Moderate; $$$$, $$$$$ - High. Source: Cardno, infra

References Cited

[2] Biohabitats *Algal Turf Scrubber Feasibility Study,* [3] ConTech supplementary product documents

[4] DEMLR Stormwater BMP Manual, [5] Tetra Tech *North Carolina Piedmont Nutrient Load Reducing Measures Technical Report*

Universal References

Cardno /Center For Watershed Protection *Findings of the Screening-Level Analysis to Select Priority Measures*

Division of Water Resources *Model Program for Existing Development Stormwater For Falls and Jordan Watersheds*

In addition to the ongoing nutrient credit development work described above there are also recent and ongoing improvements to stormwater treatment technologies in the DEMLR Stormwater BMP Manual that have applicability in both new development and existing development settings. Some of these efforts overlap with the Division crediting process, and DEMLR stormwater staff are working closely with the Division and UNRBA on these practices and accounting tools as DEMLR also seeks to codify practice criteria in rule to comply with recent legislative mandates. These improvements are summarized in Table 11.

TABLE 11. UPDATES TO DEMLR STORMWATER BMP MANUAL.

Permeable Pavement is assigned nutrient removal credit	October 2012
Manual revised to update nutrient removal efficiencies for bioretention, stormwater wetlands, filter strips, grassed swales, and permeable pavement options.	December 2012
Disconnected impervious surfaces chapter added, identifying nutrient removal credits	April 2014
Rainwater harvesting chapter added, identifying nutrient removal credits	April 2014
Memorandum of Approval (DWR and DEMLR) for designs using Storm-EZ and volume matching to be considered as meeting nutrient export requirements without making offset payments.	May 2014
Public notice of immediate applicability of minimum design criteria for stormwater control measures, which simplifies the design requirements for measures that may be credited with nutrient removal.	March 2015
Manufacturers of proprietary stormwater control measures have indicated interest in seeking nutrient removal credit for slight modifications to their equipment. Additional approved proprietary technology would expand the designers' options for nutrient control. The likelihood of an economically feasible set of target installations and matching proprietary equipment seems good.	pending
Rules review process underway for stormwater control regulations, which could update nutrient removal technology and the process for approval of new stormwater treatment technologies.	pending

Programmatic Measures Implemented by Local Governments

The Division…shall address…assessment of the instream benefits of local programmatic management measures…"

An area of interest during the Falls rulemaking for its potential nutrient credit value was that of programmatic management activities conducted by local governments. Programmatic practices under discussion included street sweeping improvements, illicit discharges to the storm sewer system, fertilizer ordinances, and pet waste ordinances.

The Division and the UNRBA are working together to establish nutrient reduction credit for additional programmatic measures to expand the number of cost-effective tools available to assist local governments to address their existing development load reduction requirements. In the meantime the Division has reached out to the local governments in the watershed to collect information about any programmatic practices they are currently implementing and whether they are conducting instream monitoring to determine benefits of implementing these practices. Based on the responses, it appears many local governments in the watershed are implementing, at a minimum, some form of street sweeping and illicit discharge and elimination (IDDE) program. Others have additional measures in place such as programs or ordinances addressing pet waste and fertilizer application on lands managed by the city of county. Programmatic measures currently implemented by local governments in the Falls watershed are summarized below in Table 12.

TABLE 12. PROGRAMMATIC PRACTICES IMPLEMENTED BY FALLS LOCAL GOVERNMENTS.

Local Government	Programmatic Practice
Butner	IDDE Program
Creedmoor	Improved Street Sweeping, Pet Waste Ordinance, IDDE Program, Fertilizer Ordinance for City Property, Yard Debris / Storm drain Ordinance
Durham	Public Education on Sanitary Sewer Overflows, Improved Street Sweeping, Stormwater system cleaning (Vactor trucks), Pet Waste Program, Dry Weather Outfall Screening Program, Collection System Inspections, IDDE Program, Yard Waste Program, Land Conservation, Nutrient Credit RFP, Comprehensive Watershed Planning for Retrofit Project Identification.
Hillsborough	Collection System Inspections , Leaf Collection, Street Sweeping
Raleigh	Public Education Sanitary Sewer Overflows, Collection System Inspections , Leaf Collection, IDDE Program, Street Sweeping, Land Conservation
Roxboro	Pet Waste Ordinance, Collection System Inspections, Street Sweeping, Leaf Collection
Stem	None reported
Wake Forest	Public education fertilizer application, Street Sweeping
Durham County	Voluntary Citizen Fertilizer Reduction
Franklin County	Illicit discharge detection & elimination
Granville County	Increased Septic Inspections Programs
Orange County	IDDE Program, Collection System Inspections
Person County	Septic Remediation Grant Program
Wake County	IDDE Program

Assessment of Instream Benefits of Programmatic Measures

There have been no watershed-specific studies to quantify the instream nutrient reduction benefits from implementing programmatic management measures. Lacking studies, the ongoing evaluation of practice creditability and development of credit estimates is proceeding based on the availability of research findings and accounting methods from similar physiographic regions elsewhere, particularly the Chesapeake watershed.

It is worth recognizing that monitoring data has been collected by the City of Durham over several years which provides insights into other water quality benefits of such practices. Monitoring in Ellerbe Creek conducted by Durham beginning in the 1990's shows a decline in fecal coliforms between 1992 and 2012. Similarly, monitoring by the Upper Cape Fear River Basin Association in Third Fork Creek in the Jordan watershed during this same time period shows a decline in total nitrogen. In both cases improvement in water quality is believed to be likely due to a combination of factors including increased public awareness, implementation of illicit discharge control programs in 1999, and a reduction in sanitary sewer overflows.

As follow up to this work, in 2011 the City of Durham helped fund a year-long preliminary assessment of nitrate sources conducted by the US Geological Survey in three creeks in Durham that feed Falls and Jordan lakes. The assessment found that the highest nitrate concentrations came from natural sources of nitrate such as nitrification of soil nitrogen and atmospheric deposition (McSwain and Young, 2014). A total of 32 samples were collected from the three streams, two urban and one rural. Of the 32 samples, 20 showed nitrate sources from soil nitrogen, and 8 detected nitrate from a mixture of soil nitrogen and precipitation. Only one sample detected nitrates from fertilizer and one from manure/sewage. Results from this preliminary work show it is possible to distinguish sources of nitrogen using stable isotopes.

Stormwater Retrofitting of Existing Developed Areas

In addition to implementation of programmatic measures already in place, many communities are already actively planning retrofit projects that can be credited towards their existing development requirements once they are fully established, even as work continues to establish nutrient credit for additional measures. In some cities, projects are in various stages of development (land acquisition, preliminary design, funding). The city of Creedmoor and Durham have indicated they are both planning regional wetlands and wet ponds to treat substantial areas. In recent years, the City of Durham in particular has been implementing a number of pilot projects and grant projects to implement practices that reduce stormwater volume and/or reduce nutrient concentration. The following projects have been completed by the City of Durham in the Falls Lake watershed:

- Soil and Water Conservation Districts in Durham County have been implementing CCAP projects that include rain gardens, cisterns, permeable pavement and other practices that mitigate the impacts of stormwater runoff.
- Two existing wet ponds were retrofitted with floating treatment wetlands, with monitoring by NCSU to assess the reductions in TSS, nitrogen and phosphorous (Hillandale Golf Course and NC Museum of Life & Science).
- Installation of a green roof and bioretention cell at the West Village redevelopment of an old cigarette factory.
- Funding of third-party installation of rain gardens (Ellerbe Creek Watershed Association and Durham Soil and Water Conservation District).
- A bioretention area was constructed in Central Park as part of a stream restoration on a tributary of South Ellerbe Creek.

- Several pocket wetlands were constructed in Northgate Park treating runoff entering Ellerbe Creek as part of a stream restoration project.
- Three additional stream restoration projects: Goose Creek (Long Meadow Park and Eastway Elementary School), Ellerbe Creek (ECWA 17 acre wood), and Lick Creek (SWCD Olive Branch Rd.)

Looking ahead, Durham is now in the post-implementation phase of evaluating the instream effect of a "Rain Catchers" project that focused on reducing stormwater volume and nutrient loading though voluntary retrofitting of micro-scale stormwater practices around homes in a small catchment. Completed in 2014, the retrofitting phase of the project used an innovative reverse auction to initiate community engagement, and identified 94 homeowners willing to host practices on their property and also willing to sign ten-year maintenance agreements. A component of the project conducted by NCSU implemented and monitored the performance of downspout disconnection at six properties. In total, 253 practices were installed to capture stormwater and reduce volume. Post-implementation monitoring will begin in 2016 to assess the overall instream benefits of the Rain Catchers project.

In 2014 Durham also started a pilot-scale Algal Turf Scrubber project on the shore of Falls Lake. Within the last quarter, continuous operation of the scrubber began and it is now being operated and monitored, growing and harvesting algae as a means of removing nutrients from the Lake. Water is pumped from Falls Lake into a linear system that sheets continuous flow over a substrate on which macrophytic algae colonize and grow, and from which the algae can be regularly and easily removed. While evaluation of this technology is ongoing, if results show removing nutrients by harvesting algae proves to be cost-effective, it could lead to construction of full-scale facilities.

A map of all of Durham's retrofit and restoration projects treating existing development stormwater is provided in Appendix 4 of this report.

Updates to Accounting Tools

"The Division…shall address…updates to nutrient loading accounting tools"

Summary

Rule compliance accounting is accomplished through the use of different accounting tools for each source type. Wastewater loading estimates rely on actual end-of-pipe monitoring combined with relatively simple assumptions and mathematical calculations, providing the most certain source loading estimates. Wastewater accounting and annual reporting is in place and no significant improvements are considered necessary. Nonpoint source load estimates inherently involve more uncertainty, and nonpoint management science and accounting tools are evolving. For the regulated Falls nonpoint sources, tools are in place and being used for agriculture, new development stormwater, and existing development stormwater. At the same time, improvements are being completed to the current site-level stormwater tool, a potential replacement tool is in the planning stages, and a watershed-scale practice crediting and tracking tool is also under development. The following is an overview of these accounting tools and a brief summary of recent and anticipated developments.

Jordan/Falls Stormwater Nutrient Load Accounting Tool

The Jordan/Falls Stormwater Tool is a site-level runoff load estimator used by developers to determine site load reduction needs and demonstrate compliance with the New Development rule nutrient export targets, but can also be applied to existing development to calculate reduction credit for stormwater BMP retrofits. Improvements to the tool were initiated in 2013 and it is nearing completion as final beta-testing issues are resolved.

Jordan / Falls Stormwater Tool introduces a new innovation that moves away from the fixed percent nutrient removal efficiencies used in most stormwater tools. It instead assumes fixed effluent concentrations specific to individual BMPs regardless of influent concentration, an approach that more accurately represents stormwater treatment processes as determined by substantial research in-state corroborated by findings nationally and internationally. This methodological change better reflects the greater treatment efficiencies seen on sites with higher runoff nutrient concentrations. A second advancement incorporated into the design of the tool is adding explicit estimation of and accounting for the infiltration that occurs as stormwater passes through a BMP, crediting this loss of volume toward nutrient load reduction.

Most notable of current tool improvements are the ability to estimate credit for an oversized or undersized practice, which is especially useful for existing development retrofits, and the addition of several BMPs including a custom BMP option that allows user specification and credit estimation for emerging and future creditable practices. In additions, refinements have been made to concentration values for several land covers and BMPs, and numerous user-friendliness improvements were made.

Storm-EZ Tool

Storm-EZ is another site-level runoff estimator that currently focuses entirely on hydrology and can be used by developers to demonstrate compliance with Low Impact Development criteria. Use of Storm-EZ is voluntary. In May 2014 Falls Lake local governments were notified that the Division would accept the results of the Storm-EZ tool with some adjustments for nutrient compliance on developments that meet LID criteria. The Division is currently in discussions with DEMLR concerning a merger of the Jordan/Falls Tool and Storm-EZ into a single combined tool for all stormwater programs to improve efficiency and utility to the development community and local governments for both new and existing development.

The Storm-EZ tool is based on the Natural Resources Conservation Service discrete curve number method and current research on stormwater control measures. Designers enter data about the site plan and the stormwater control measures that will be used. The tool then reports how closely the project matches the pre-development runoff volumes. Storm-EZ can also be used to judge compliance with the "basic treatment" approach (85 percent TSS removal) or a hybrid approach of low impact development practices used in conjunction with basic treatment.

UNRBA Credit Tool

The UNRBA Credit Tool is based off a modified version of the Watershed Treatment Model (WTM) developed by the Center for Watershed Protection, Inc. It is a spreadsheet-based tool under development by the UNRBA to facilitate existing development rule compliance. It will accept the BMP credit outputs of site-level stormwater tools and add the ability to estimate credit for watershed-scale programmatic practices and non-urban practices as well as estimate delivered load reductions to Falls Lake. It provides for tracking and reporting all practices. The tool should play a valuable role in rule implementation. The development of the modified WTM tool is ongoing with an expected completion date of late 2016.

Nitrogen Loss Estimation Worksheet

The agricultural sector uses the Nitrogen Loss Estimation Worksheet (NLEW) to track progress towards achieving the required nitrogen reductions under the collective compliance approach provided in the Falls Lake agriculture rule. NLEW is an empirical spreadsheet-based estimator of N loss from edge-of-field that captures changes in loss from changed application rates, changes to crop acres and BMP implementation. For rule compliance a county-scale version is run annually and results compared to baseline values. There have not been any updates to the tool since the rule went into effect in 2001, but the N.C. Division of Soil and Water Conservation has recently secured funding to update the tool during the winter of 2016. Planned updates to the NLEW tool include:

- Updates to realistic yield expectations (RYE) for current crops
- Updated soil management groups
- Development method for adding RYE for new crops in future years
- Simplification and automation of data import and export
- Synchronization of data sources across NLEW and Nutrient Management Software
- Upgrades for obsolete software according to C+ programming language
- Maintenance of software code on N.C. Department of Agriculture and Consumer Services servers (currently stored on CD-ROM and N.C. State University servers)

Utilization of Nutrient Offsets & Upcoming Program Changes

"The Division…shall address…the utilization and nature of nutrient offsets and projected changes…"

and *"an assessment of any load reduction value derived from preservation of existing forested land cover."*

In the Falls Lake watershed, a developer must meet nutrient loading rate targets of 2.2 lbs. N/acre/year and 0.33 lbs. P/acre/year for stormwater exiting the property. The developer's nutrient load is calculated using the development plan and the Jordan/Falls Stormwater Nutrient Load Accounting Tool. Most developments exceed the rate targets absent any stormwater treatment practices. The Falls New Development Stormwater rule requires 30 to 50 percent of the total load reduction needs to be met onsite using such stormwater practices. Once that obligation is met, the developer may pay an in-lieu fee to purchase the remainder of their nutrient loads as credit from an offsite reduction activity to meet the loading rate targets, a process referred to as nutrient offset.

Nutrient offset has evolved in recent years through a series of session laws into a 2-option system; private offset banks and a state-run option through the N.C. Division of Mitigation Services (DMS), formerly the Ecosystem Enhancement Program. Most local government entities and all private developers seeking third party nutrient offsets must do so through a state-approved private nutrient bank within the watershed where the development project is located (G.S. §143-214.26). When credit from approved private banks is not available, seekers of nutrient offsets are eligible to participate in the DMS Nutrient Offset Program. Some local governments and state and federal entities are exempt from this requirement and may choose to use either a private bank or the In-Lieu Fee program.

The predominant practice used by nutrient credit generators is conversion of farmed riparian lands into protected forested buffers that filter farm runoff. Presently these practices are credited at a rate of 75.77 lbs. N/acre/year nitrogen and 4.88 lbs. P/acre/year. Assuming a life expectancy of 30 years, riparian buffers have a lifetime credit value of 2,273 lbs. N/acre and 146.4 lbs. P/acre. While an increasing number of other practices described in preceding sections are eligible to generate nutrient reduction credit for sale, they have not typically been as cost-effective as the reforestation of riparian areas.

Nutrient Offset Utilization Trends

Four private banks have been established in the Falls Lake watershed for the purposes of nutrient offset. Three of these banks are in the upper Falls watershed. Additionally, DMS has two nutrient offset sites in the upper watershed. As of June 30, 2015, all private banks and one of two DMS projects have completed in-ground restoration at their respective sites. An overview of all nutrient transactions from the banks and DMS projects is provided in Table 13.

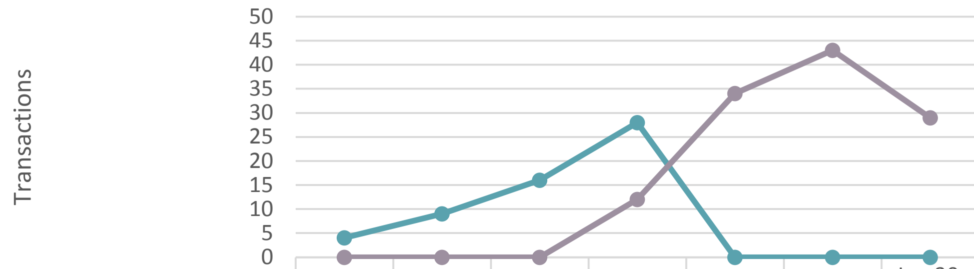
TABLE 13. THIRD-PARTY OFFSITE FALLS LAKE WATERSHED NUTRIENT TRANSACTIONS THROUGH JUNE 30, 2015.

	Nitrogen	Phosphorus
Private bank transactions	65	53
Private bank credits (lbs.)	35,948	3,244
Private bank acres mitigated (ac)	15.82	22.16
DMS transactions	42	15
DMS credits (lbs.)	14,818	414
DMS acres mitigated (ac)	6.52	2.83
All transactions	107	68
Total credits (lbs.)	50,766	3,6458
Total acres mitigated (ac)	22.34	24.99

Nutrient credits have been sold in the Falls Lake watershed as early as 2009 to facilitate compliance with the Neuse nutrient strategy stormwater rule, with DMS responsible for the bulk of these transactions through 2012. However, with the legislative establishment of a preference for private bank credits and the approval of the four private mitigation banks, in-lieu fee payments to DMS have virtually halted in the Falls Lake area (Figure 12).

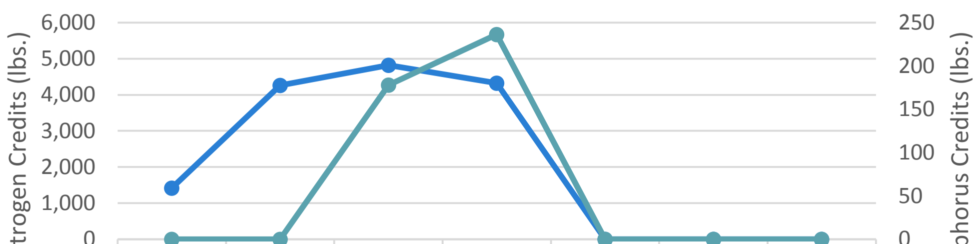
The rate of nutrient transactions and number of credits sold appears to be generally increasing in the watershed largely precipitated by implementation of the Falls new development rule. Through June 30, 2015, the number of nutrient transactions and credits sold in 2015 are on pace to significantly eclipse prior years.

FIGURE 11. NUTRIENT OFFSET TRANSACTIONS IN THE FALLS LAKE WATERSHED.



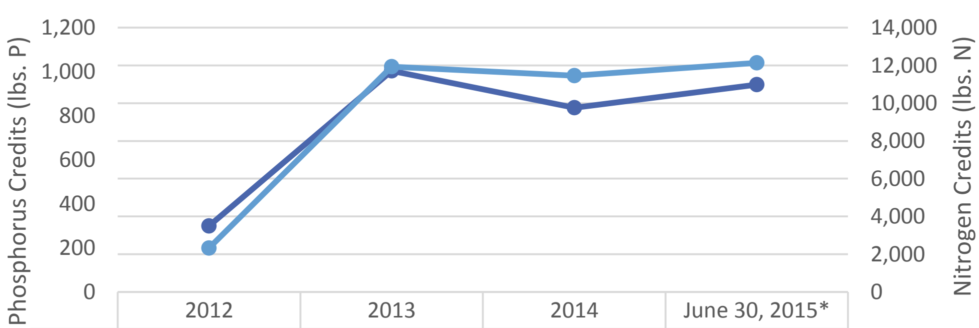
	2009	2010	2011	2012	2013	2014	Jun 30, 2015*
DMS (N & P)	4	9	16	28	0	0	0
Private banks (N & P)	0	0	0	12	34	43	29

FIGURE 12. DMS IN-LIEU FEE NUTRIENT OFFSET CREDITS IN THE FALLS LAKE WATERSHED.



	2009	2010	2011	2012	2013	2014	Jun 30, 2015*
N	1,419	4,259	4,818	4,322	0	0	0
P	0	0	178	236	0	0	0

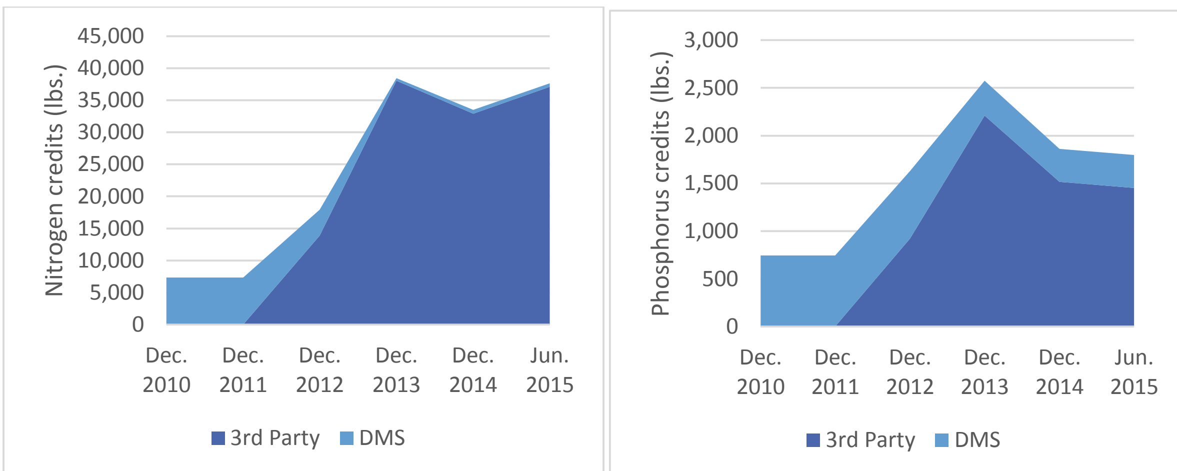
FIGURE 13. PRIVATE BANK NUTRIENT CREDITS SOLD IN THE FALLS LAKE WATERSHED.



	2012	2013	2014	June 30, 2015*
N	3,501	11,708	9,763	10,975
P	198	1,023	983	1,041

These graphics illustrate the course that the current 2-option system has taken to date in Falls watershed. This trend, however, is not necessarily a good predictor of the future. Development activity may prove sufficient to support both private and state projects. Also, while one positive aspect of private banks from the Division's perspective is that their actual load reductions begin in advance of the reduction needs they satisfy, a potential disadvantage of private banks in general is that they may find the credit demand rate in low-activity watersheds to be insufficient to merit the gamble on profitability, and may thus may not be established where developers nevertheless need an offset option. In those cases, DMS may be willing to take payments toward a project thereby filling a service gap. This scenario does not appear to be the case in Falls watershed, but it is a potential factor to be aware of.

FIGURE 14. NITROGEN AND PHOSPHORUS CREDIT AVAILABILITY IN THE FALLS LAKE WATERSHED.



Projected Changes to Nutrient Offsets

Regarding projected utilization of offsets, two primary factors may affect demand for offset credits in the Falls watershed: development trends and the emergence of cost-effective alternatives to offsets. We would anticipate the development trend in the watershed to continue following the general slow economic improvement pattern presently occurring, and we have not developed more involved projections for this report. Regarding the second factor, the only potential alternative to offsets would be achieving greater reductions on site. Some improvement to on-site options may emerge in the coming years associated with the efforts described in preceding sections to expand the toolbox of practices and improve accounting. Specifically, practices under development include variants to conventional stormwater BMPs that will accommodate varying site constraints by allowing variations in practice design specifications and tying those variations to nutrient performance. While this is being driven by existing development site constraint interests, it will also allow for oversizing a practice where feasible on a new development for extra credit. This may allow for greater levels of compliance on site.

Another ongoing development is the addition of nutrient practice types that can apply to new development, such as disconnection of impervious surfaces and infiltration practice options.

One other factor that could play into the cost-effectiveness aspect of alternatives is reduced cost-effectiveness of the current default practice of buffer restoration. One recommendation under consideration by the Division is a transition away from providing static, pre-set literature-based nutrient credits on a per-acre basis. This potential change is motivated by the accumulation of additional science that suggests the need for a more site-specific approach that would nevertheless provide predictability based on a defined method. Among its benefits, this change has the potential to encourage innovation and incentivize the restoration of high-quality buffers by mitigation bankers. However, this change is generally projected to lower the per-acre number of nutrient credits, which could result in an increase in offset rates or a reduction in the number of riparian restoration projects implemented. Such an increase has the potential to make other nutrient-reducing practices, including stormwater BMPs, more financially competitive with buffer restoration.

Regarding potential changes to the nature of offsets, while revised buffer restoration crediting may diminish its value somewhat, other offsite practices or buffer variants currently being evaluated for nutrient credit may affect outcomes. These include credit for livestock exclusion from streams and credit for hydrologic restoration of buffer function. Other offsite practices under development such as stream restoration and cropland conversion to trees are perhaps less likely to compete with buffer restoration from a nutrient cost-effectiveness standpoint and from an availability standpoint.

Altogether, expanded on-site options and potentially less attractive offsite options may combine to damp a generally increasing trend in offset needs tied to the improving economy. This discussion has also highlighted potential changes to the nature of offsets via diversification in practices driven by, and likely more useful for, existing development but having some potential utility in new development settings as well.

Regarding the second report subject area tied to nutrient offset, *"an assessment of any load reduction value derived from preservation of existing forested land cover,"* discussions have recently begun between Division staff and stakeholders on this topic. By definition nutrient loading to streams and Falls Lake cannot be reduced by preserving existing uses, including forest preservation. However, forest preservation reduces the amount of land that may ultimately be developed otherwise, and push development to convert greater proportions of higher loading farmland instead. The result would be some amount of extra load reduction through that development being held to rule-set loading rates that were based on assumptions of less development of higher loading lands. The significance of this potential credit is currently being evaluated.

Otherwise we recognize that under the right circumstances preservation of forest land can help protect waters from load increases that can occur associated with hydrologic changes brought on by development. However the potential for crediting forest preservation for load reductions toward restoration goals is to date not reconciled with such protection from possible increases, and stakeholder discussions are ongoing.

Atmospheric Deposition Trends

"The Division…shall address… results of applicable studies, monitoring, and modeling from which a baseline will be established to address changes in atmospheric deposition of nitrogen"

"The Division…shall address… recent or anticipated changes in regulations affecting atmospheric nitrogen emissions and their projected effect on nitrogen deposition"

Summary

A weight of evidence compiled for this report from deposition data and air modeling results indicates a promising downward trend in recent atmospheric nitrogen deposition in the Falls watershed. Modeling estimates a 15 percent decline in the watershed since the 2006 baseline. Looking forward, the expected maturation of prior air emissions regulatory initiatives and new ones in progress together suggest further reductions are likely. It is worth noting that the not-insignificant uncertainties associated with these estimates are not expected to improve absent new funding for additional monitoring.

Relevance

Atmospheric deposition of nitrogen was an input included in the development of both the Falls watershed loading and Falls Lake response models. The lake response model was used to set strategy reduction goals, so decreases in atmospheric deposition could potentially lessen the magnitude of source reductions needed to recover the lake.

Atmospheric N Basics

Atmospheric nitrogen is comprised of a host of parameters, many of which are minor transformational variations of others, but they can all be sorted into two basic distinctions, oxidized and reduced compounds. Oxidized N compounds (e.g. NO_x) result primarily from combustion activities, most of which are anthropogenic. Oxidized forms generally mix better and are less reactive and thus have larger, multi-state airsheds. Reduced N compounds (largely ammonia NH_3 and ammonium NH_4^+) volatilize from organic sources, mostly animal waste and to a lesser extent fertilizer, so primarily CAFOs but more generally agriculture are the dominant sources in North Carolina. They generally travel shorter distances, are considered “stickier” and more reactive and thus have smaller airsheds and more locally variable concentrations. In the most general terms, on a regional scale neither form consistently dominates in our region and both forms matter. Atmospheric N is delivered in two ways, wet and dry deposition. Dry is generally less easily measured and is thus less well-understood.

Deposition Data

Atmospheric data utilized in both Falls water quality models came from two primary sources, each with one station in the vicinity: The National Atmospheric Deposition Program (NADP) and the Clean Air Status and Trends Network (CASTNET) (Division of Water Quality Modeling/TMDL Unit, 2009b). Each of the two monitoring stations regularly measures select atmospheric nitrogen compounds (Table 14). Neither station measures all nitrogen compounds - certain absent parameters are significant (but impractical to measure), so the data record is incomplete but it is nonetheless considered useful for assessing trends. Annual averages from these two stations were evaluated to determine whether significant trends are present.

The NADP station NC41 is located at Finley Farms in Wake County, just a few miles south of the Falls Watershed. CASTNET station PED108 is located 65 miles north of the watershed in Prince Edward County, Virginia.

Station NC41, while much closer to the Falls Lake watershed, provides only wet deposition data obtained through analysis of nitrogen compounds in precipitation. Conversely, station PED108 provides estimates of wet and dry atmospheric nitrogen deposition but is further from the Falls Lake watershed.

Particular caution is warranted in extrapolating conclusions from station PED108. The station’s rural, forested location contrasts with the mixed land use types of the Falls Lake watershed. While atmospheric nitrogen concentrations are measured here and at CASTNET stations nationwide, deposition velocity is modeled based on surrounding land uses within a 1 km radius. Therefore, dry nitrogen deposition estimates at these stations are strongly dependent upon surrounding land use types. Furthermore, geographic distance and modeling outputs suggest that PED108 and the Falls Lake watershed are in different emissions airsheds, further limiting the station's utility in assessing Falls Lake trends. Despite these concerns, the site remains the nearest and best source of dry deposition monitoring for Falls Lake.

Air Modeling

Atmospheric modeling is another technique that can be used to estimate atmospheric nitrogen deposition trends. To provide a third line of analysis of those trends in the Falls Lake watershed for this report, results were harvested from EPA's continental-scale Community Multiscale Air Quality modeling system (CMAQ), which uses natural and anthropogenic emissions to predict the fate of chemicals in the atmosphere (Byun & Schere, 2006). Twelve (12) km^2 gridded spatial estimates of nitrogen deposition are among the many outputs of the CMAQ model. The model run also incorporated a NH_3 bi-directional flux model which more accurately accounts for agricultural fertilizer emissions (Appel et al., 2011; Cooter, Bash, Walker, Jones, & Robarge, 2010). Results were post-processed using NADP data to correct for precipitation errors and biases in the wet deposition (D. Schwede, personal communication, December 1, 2015). Model outputs from 2006 and 2011 (the latest available) were finally clipped to the Falls Lake watershed and averaged spatially.

Weight of Evidence Results

Values from these three information sources – two stations and model - are not directly comparable, as the calculation of nitrogen deposition involves measurements (or models) of different nitrogen compounds, using different techniques, in different places. Nevertheless, each source serves as an indicator of deposition trends in the watershed, and their collective results can be taken from a weight-of-evidence perspective.

TABLE 14. ATMOSPHERIC NITROGEN COMPOUNDS AND DATA SOURCES.

Compound	Name	Reduced or oxidized N?	Wake County NADP (station)	Prince Edward County CASTNET (station)	CMAQ (model)
NH_3	ammonia	reduced	N	Y, wet & dry	Y, wet & dry
NH_4^+	ammonium	reduced	Y, wet	Y, wet & dry	Y, wet & dry
TNO_3 ($HNO_3 + NO_3^-$)	total nitrate (nitric acid + nitrate)	oxidized	Y, wet (NO_3^- only)	Y, wet & dry	Y, wet & dry
PAN	peroxyacetyl nitrate	oxidized	N	N	Y, wet & dry
ORGN	oxidized organic nitrogen	oxidized	N	N	Y, wet & dry
NO_x ($NO + NO_2^-$)	nitrogen oxides (nitric oxide + nitrite)	oxidized	N	N	Y, wet & dry
N_2O_5	dinitrogen pentoxide	oxidized	N	N	Y, wet & dry
HNO_2 (*HONO*)	nitrous acid	oxidized	N	N	Y, wet & dry
HNO_4	peroxynitric acid	oxidized	N	N	Y, wet & dry

Considering weight of evidence across the two stations and the model, reduced nitrogen trends are generally inconclusive. Comparisons between 2006 and 2011 CMAQ model outputs show a 9.9% increase in reduced nitrogen over that time period. NC41 monitoring data also shows a slight but statistically insignificant increase in wet reduced N deposition. Station PED108 shows no notable trends for wet NH_4 deposition or total NH_4 deposition. A statistically significant ($p < 0.05$) decrease in dry NH_4 deposition was found, but this figure only accounts for 10-31% of total ammonium deposition at the site in any given year.

The weight of evidence for oxidized N is much clearer; based on the three data sources, oxidized N deposition has shown marked declines since 2000. Station NC41 shows a statistically signficant decrease in wet nitrate deposition, with a 44% reduction between 2000 and 2014. CMAQ modeling estimates a 25% reduction in total nitrate deposition. Station PED108 also reflects statistically significant decreases in wet NO_3, dry HNO_3, and total oxidized nitrogen deposition.

Combining the results for reduced and oxidized forms, total nitrogen deposition in the watershed may also be declining, due primarily to the downward trend in nitrate deposition. CMAQ models a 15.5% reduction in total nitrogen deposition in the Falls Lake watershed, and station PED108 shows a statistically significant decrease in total nitrogen deposition. Station NC41 shows a slight but statistically insignificant decrease in total wet nitrogen deposition.

Figure 15. Air Quality Monitoring Station Trends near the Falls Lake Watershed. (*statistically significant change, p<.05)

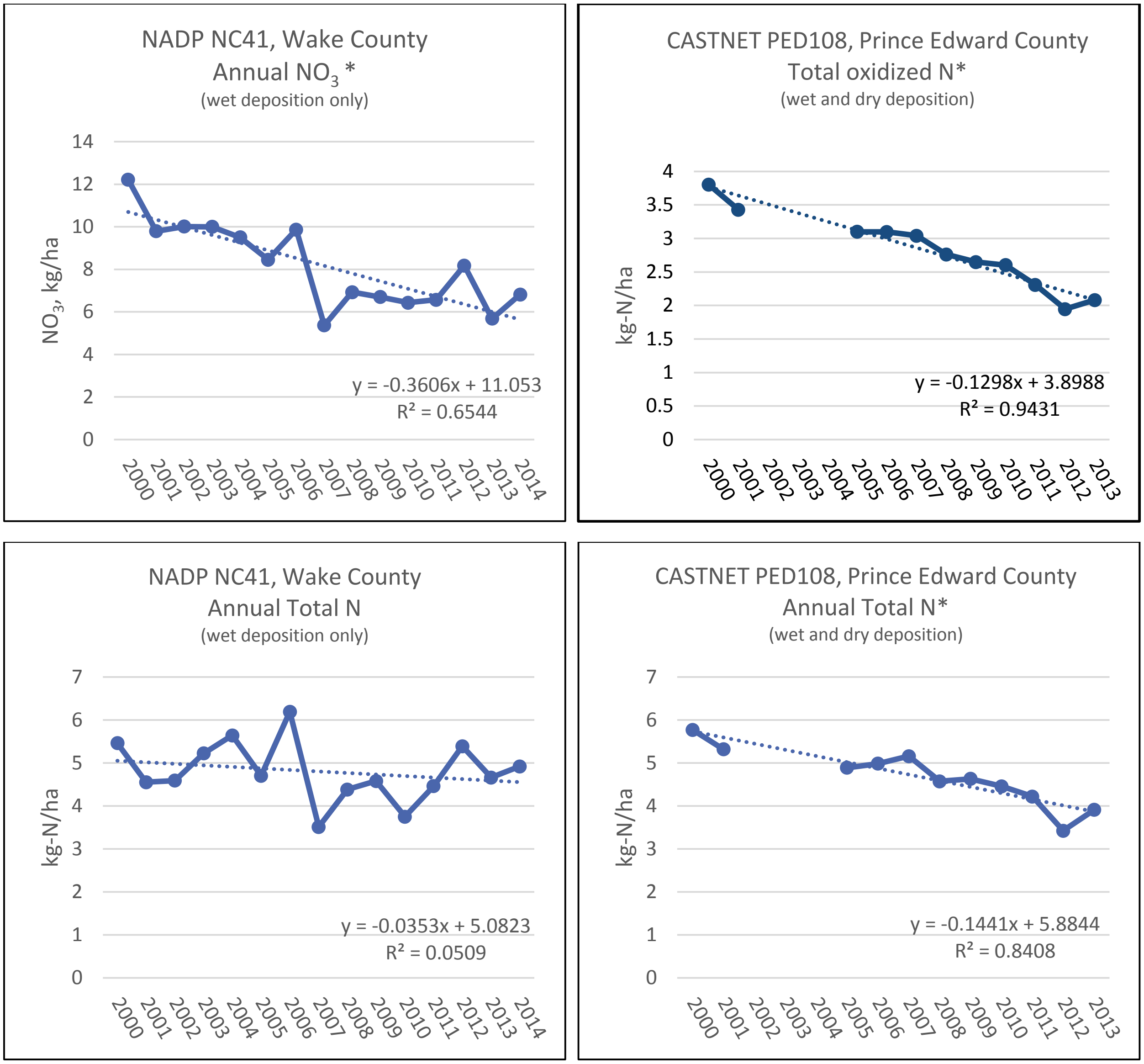


Table 15. CMAQ nitrogen deposition estimates (kg-N/ha).

	2006	2011	Change
Adjusted wet deposition, reduced N	2.24	2.31	2.7%
Dry deposition, reduced N	0.93	1.19	27.1%
Total deposition, reduced N	3.18	3.49	9.9%
Adjusted wet deposition, oxidized N	2.15	1.75	-18.6%
Dry deposition, oxidized N	6.63	4.87	-26.7%
Total deposition, oxidized N	8.78	6.62	-24.7%
Total deposition, N	11.96	10.11	-15.5%

Regulatory Drivers and Outlook

Nitrate deposition reductions are likely due to several state and federal air quality initiatives. Atmospheric NO_x contributes to elevated ozone levels, which have adverse human health effects. NO_x is emitted from the combustion of fossil fuels, including in electric utilities and motor vehicles, and is also a byproduct of natural lightning strikes and burning of biomass. While NO_x reductions can be attributed to many factors, the N.C. Clean Smokestacks Act is particularly notable for its requirement, now met and exceeded, for coal-fired power plants to reduce NO_x emissions by 77 percent by 2009 (North Carolina Department of Environment and Natural Resources, 2015).

Looking forward, other regulatory initiatives designed to curb motor vehicle and interstate power plant emissions are likely to further reduce nitrate deposition in the Falls watershed as their requirements are implemented. In addition, a recently settled lawsuit between North Carolina and the Tennessee Valley Authority will result in the reduction and capping of NO_x sources by 2018 and installation of modern pollution controls for TVA's facilities (North Carolina Department of Environment and Natural Resources, 2015).

Atmospheric modeling research continues to advance, and at national scales new methods for combining model and monitoring outputs are being explored (Schwede & Lear, 2014). Regional proposals for finer scale models runs are under consideration, and modeling estimates can be further refined by incorporating updated land cover data (D. Schwede, personal communication, December 1, 2015). Hindcasting studies comparing model outputs with prior monitoring data can also help improve model confidence, albeit at larger scales than the Falls watershed (e.g., Bash, Cooter, Dennis, Walker, & Pleim, 2013). Finally, local and regional research efforts may also enhance our knowledge in this area.

In contrast, funding for maintenance of existing air quality monitoring stations is often uncertain and establishment of new air quality monitoring stations is rare, particularly in support of watershed management. The quality of monitoring information available to inform Falls Lake approaches, or those in North Carolina's nutrient strategy watersheds generally, is unlikely to improve absent additionalinvestment.

Summary of Studies Evaluating Nutrients from Groundwater

"The Division…shall address… results of any studies evaluating nutrient loading from groundwater"

Groundwater discharge to surface water is potentially one of the largest nutrient fluxes in the environment (Robert W. Howarth, Boyer, Pabich, & Galloway, 2002). Reviews of nitrate contamination in the United States have found a relationship between regional nitrogen loads to groundwater and nitrogen loads in corresponding surface water discharges (R. W. Howarth et al., 1996; Smith, Schwarz, & Alexander, 1997).

Pollutants delivered through groundwater flow, such as nitrate, are generally delivered at much slower rates than those in surface water but can be major contributors to a basin's overall loading. For example, the Scientific and Technical Advisory Committee of the Chesapeake Research Consortium estimated in 2005 that 40 percent of all nitrogen reaching the Chesapeake Bay had travelled through groundwater before reaching the bay.

Concentrations of nutrients in groundwater can vary greatly with respect to land use, fertilizer and residuals application rates, and nutrient management practices within a watershed. Nutrient inputs to groundwater systems can be grouped into five general categories: precipitation, point-source discharges, crop-fixed nitrogen, commercial fertilizer, and animal waste (G. McMahon & Lloyd, 1995). Generally in North Carolina basins, nitrate concentrations are highest in groundwater near the surface in areas where contamination sources are present in higher densities, particularly in agricultural and urban areas (Harned, McMahon, Spruill, & Woodside, 1995).

Recent studies have used new scientific methods to age-date nitrogen found in groundwater discharging to surface water systems. They indicate that nitrogen pollution entering surface water through baseflow can vary greatly in its age, with lag times between recharge and discharge on the scale of decades. A recent study by Kennedy et al. (2009) in the North Carolina coastal plain used chlorofluorocarbons and dissolved gas modeling to date nitrogen-laden groundwater contributing to the Bear Creek watershed. Results indicated that groundwater discharge ranged in age from 10 to 60 years old. This lag time suggests that in areas where reductions in nutrient application have been prioritized, resulting improvements in surface water quality should be expected to occur over the course of decades. Oenema et al. (2005) found that reductions in excess agricultural nitrogen and phosphorous through chemical fertilizer applications resulted in limited immediate improvement in surface water quality due to the presence of other contaminant sources and the discharge of nutrient rich groundwater predating the reductions.

Kennedy et al (2009) also showed a 50 percent reduction of nitrate concentrations in groundwater before discharge as a result of denitrification within the aquifer and in the riparian zone. Similar results were found by McMahon et al. (1996)in the South Platte River (Colorado), where denitrifying activity in the floodplain and in sediments reduced baseflow nitrate loading by 70 percent compared to predictions based on median concentrations within the aquifer. Ultimately groundwater was found to contribute 18 percent of the river's nitrate load, significantly less than would be expected in the absence of denitrification within the aquifer.

Spruill et al. (2005) characterized the fate and transport of nitrogen from a concentrated animal feeding operation to surface waters in the Neuse River basin. This study used chlorofluorocarbons, tritium, and silica to estimate residence times and date groundwater within the system. Groundwater within the system was up to 30 years old, but age varied significantly based on the geophysical characteristics of each site sampled. Groundwater less than 10 years old contained elevated dissolved oxygen and nitrate concentrations, while groundwater dated between 10 and 30 years old had low dissolved oxygen and low nitrate. Nitrate from a shallow surficial aquifer was heavily denitrified once entering the riparian zone, contributing little to total stream nitrogen loading. Conversely, shallow groundwater intersecting a tile drainage system significantly contributed to instream nitrogen concentrations, accounting for approximately 30 percent of the increase in nitrate flux observed along the given reach. This difference emphasizes the spatial heterogeneity of potential groundwater influences on surface water quality depending on both nutrient management practices and physical landscape characteristics.

These studies and others like them (Böhlke, Harvey, & Voytek, 2004; Burns, 1998; Chestnut & McDowell, 2000) suggest that geophysical and chemical properties of the aquifer, groundwater residence time, and the presence of a riparian buffer affect the nutrient composition and water quality of baseflow entering a surface water system. While these results provide some insights, they were largely conducted in the coastal plain or in other geographic areas outside of the Falls lake watershed. Further research is needed to assess this flux in the piedmont to better understand loading to Falls Lake.

A recent study by Messier et al. (2014) developed a land use regression (LUR) - Bayesian Maximum Entropy (BME) model to predict point level groundwater nitrate concentrations in North Carolina using data from private drinking well and groundwater monitoring wells. The model derived from monitoring well data predicted groundwater nitrate concentrations in the Falls Lake watershed ranging from 0.04 mg/L to 114.8 mg/L with a mean predicted concentration of 0.66 mg/L. These results can be combined with the USGS baseflow index grid for the contiguous United States and USGS National Water Information System historical discharge data to estimate potential nitrate contribution to the Falls Lake watershed via groundwater discharge.

The Falls Lake watershed has a mean baseflow index of 0.295, meaning that 29.5 percent of total watershed discharge is estimated to be contributed by groundwater discharge to surface water. From 1983 to 2014, the Neuse River at the Falls Lake dam had a mean yearly discharge of 527 million m^3/year. With a predicted mean groundwater nitrate concentration of 0.65mg/L, approximately 345,000 kg/year of nitrate could be contributed by groundwater to surface waters within the watershed. However, this estimate does not account for denitrification processes within groundwater system, which have been shown by the aforementioned studies to significantly reduce nitrate concentrations before discharge to surface waters. Because these processes are dependent on several unquantified factors, additional research is needed to more accurately assess groundwater nutrient loading in the Falls Lake watershed. However, these figures can provide an order-of-magnitude estimate of groundwater nutrient contributions affecting surface water quality, perhaps partially explaining unquantified nutrient sources within the watershed and lag times observed between nutrient loading reductions and increases in surface water quality.

Summary of Studies Evaluating Nutrients from Septic Systems

"The Division…shall address… results of any studies evaluating nutrient loading from conventional septic systems and discharging sand filter systems"

Nutrient load estimates for onsite wastewater systems have been made using large-scale water quality models with wide-ranging transport assumption. Relevant field research to support nutrient transport assessments in the Piedmont has been minimal (Berkowitz, 2014). The Falls Lake watershed model suggests that residential onsite wastewater systems, both conventional septic and discharging sand filters, are potential sources of nutrients in the Falls Lake watershed.

Although malfunctioning septic systems have the potential to deliver higher loads of nitrogen and phosphorus to surface waters than functioning septic systems, the magnitude of the delivered load varies and is dependent on factors including the type of malfunction and characteristics of the soil, land, and hydrology between the systems and receiving water (Tetra Tech, 2013b).

The following is a brief summary of four relevant works that evaluate nutrient loads from these sources. In some cases, like the work performed by Tetra Tech and Hazen & Sawyer, the efforts described below encompass extensive literature reviews that capture the results of numerous studies specific to North Carolina and beyond.

Tetra Tech. North Carolina Piedmont Nutrient Load Reducing Measures Technical Report. Prepared for NCDWR. September 2013.

The Division contracted with Tetra Tech in 2012 to characterize nutrient load reduction performance associated with remedying discharging sand filters and malfunctioning septic systems (Tetra Tech, 2013b). The work included an analysis of available local data and published literature on effluent concentrations from these types of systems. The findings suggest that properly functioning conventional septic systems effectively reduce nutrients prior to surface water delivery. However, malfunctioning and discharging septic systems were determined to be potential sources of nutrients and could be replaced or remedied to earn nutrient reduction credits for existing development rule requirements.

Under the programmatic approach Tetra Tech proposed for addressing conventional septic systems, jurisdictions would be awarded credit for malfunctioning systems addressed in a given year. However, the credits are adjusted and reduced to account for the nutrient load that new unremedied malfunctions deliver. The documented improvement in malfunction rate between successive years is multiplied by the total number of septic systems in the jurisdiction to determine the annual net reduction credit. The first year's malfunction rate serves as the baseline against which succeeding years will be measured.

Table 16 below summarizes the nitrogen credit Tetra Tech proposed to be awarded for each of three proposed remedial alternatives for addressing malfunctioning septic systems. Phosphorus load reduction credits are 1.8 lbs./cap/year for remedying a direct septic tank effluent discharge, 0.88 lbs./cap/year for remedying a direct greywater discharge, and 0.54 lbs./cap/year for remedying a drainfield malfunction.

TABLE 16. TN LOAD REDUCTION CREDIT FOR REMEDYING MALFUNCTIONING SEPTIC (LBS./CAP/YEAR).

Malfunction	Repair with properly functioning septic	Connection to major NPDES system	Replace with subsurface TS-II	Replace with discharging TS-II
Direct septic tank effluent discharge	10.67	11.0	10.87	6.6
Direct greywater discharge	0.37	0.70	0.57	--
Drainfield malfunction	3.27	3.60	3.47	--

The report also provided nutrient credit recommendations for replacing discharging sand filter systems (DSFs). These systems differ from conventional onsite treatment in that they are residential wastewater treatment systems that use some form of pretreatment beyond the primary treatment a septic tank provides and are permitted to discharge to surface waters, ditches or the ground surface. There are four major types of DSFs and three possible remedies to address nutrient loading concerns.

Recommended remedies include upgrade of single-pass filters to advanced nutrient-reducing treatment systems, connection to major NPDES system, replacement with properly functioning septic system, and replacement with an advanced on-site subsurface discharging system. Credits for remedies to discharging sand filters are similar for the septic, advanced on-site, and major NPDES options, while the upgrade from a single-pass filter to advanced treatment warrants modest TN reduction credits. Recommended nutrient load reductions for remedying DSFs are summarized in Tables 17 and 18 for TN and TP, respectively.

TABLE 17. TN LOAD REDUCTION CREDIT FOR REPLACING DISCHARGING SAND FILTERS.

System	DSF loading rate	Upgrade to discharging TS-II equivalent	TS-II with subsurface soil dispersal	Connection to major NPDES system*
	(lbs./cap/year)	(lbs./cap/year)	(lbs./cap/year)	(lbs./cap/year)
Remedy loading rate		4.4	.13	--
Types of DSFs		Remedy load reduction credit (lbs./cap/year)		
Single-pass with regular discharges	7.4	3.0	7.3	7.4
Single-pass with no or infrequent discharges	7.4	3.0	7.3	7.4
Recirculating filters and other advanced discharging systems	4.4	--	4.3	4.4
Malfunctioning discharging systems	7.4	3.0	7.3	7.4

** Assumes all load transferred to major NPDES sector*

TABLE 18. TP LOAD REDUCTION CREDIT FOR REPLACING DISCHARGING SAND FILTERS.

System	DSF loading rate	Upgrade to discharging TS-II equivalent	TS-II with subsurface soil dispersal	Connection to major NPDES system*
	(lbs./cap/year)	(lbs./cap/year)	(lbs./cap/year)	(lbs./cap/year)
Remedy loading rate		1.8	0	--
Types of DSFs		Remedy load reduction credit (lbs./cap/year)		
Single-pass with regular discharges	1.8	--	1.8	1.8
Single-pass with no or infrequent discharges	0.9	(-0.9)	0.9	0.9
Recirculating filters and other advanced discharging systems	1.8	--	1.8	1.8
Malfunctioning discharging systems	1.8	--	1.8	1.8

** Assumes all load transferred to major NPDES sector*

Chesapeake Bay Program. Recommendation of the On-Site Wastewater Treatment Systems Nitrogen Reduction Technology Expert Review Panel. August 2014

The Chesapeake Bay Program Office On-Site Wastewater Treatment Systems Nitrogen Reduction Technology Expert Review Panel was formed to recommend on-site wastewater treatment technologies and best management practices for existing and new wastewater treatment systems. The panel reviewed existing scientific research and provided recommendations for TN reduction credits for specific technologies and system modifications. The panel concluded that 5 kg TN/person/year could be reasonably estimated as the nitrogen loading associated with the septic tank effluent from a conventional septic tank system. The panel agreed with the current CBPO assumption that an average TN reduction of 20 percent occurs within a conventional gravity flow drainfield. Based on these assumptions, the panel concluded that the edge-of-drainfield TN load can be estimated at 4 kg TN/person/year (Adler et al., 2014).

Hazen and Sawyer. A Review of Onsite Wastewater System Performance and Nutrient Trading Policy to Support Falls Lake Nutrient Strategy Development. City of Raleigh Public Utilities Department. January 2013.

In 2013 the City of Raleigh contracted with Hazen & Sawyer to conduct a review of onsite wastewater system performance (Sadler, Waldroup, McLawhorn, & Buchan, 2013). This work resulted in a comprehensive literature review of studies related to onsite wastewater treatment technologies, effluent quality, and treatment performance. The study resulted in a summary of effluent quality from various onsite treatment technologies and prompted discussions concerning nutrient attenuation in soil and nutrient and groundwater movement to receiving streams. It also summarized approaches, including watershed models and spreadsheet-based tools, to assess nutrient load contributions from these systems.

The report details the fate and transport of nutrients from onsite wastewater treatment system in the Falls Lake watershed. Phosphorus and nitrogen attenuation in soils is discussed, and 77 percent and 79 percent of phosphorus and nitrogen loads were attenuated in their watershed model for properly functioning septic systems. Data from sand filters is reported from 10 site visits in 2008 as 21.1 mg/L TN and 16.1 mg/L TP. The report provides a summary of minimum, average, and maximum effluent quality concentrations from on-site wastewater treatment systems and details septic system nutrient loads delivered to the downstream waters. Appendix A of the report contains a comprehensive summary of effluent quality data for onsite wastewater treatment systems.

NC DHHS, On-Site Waste Water Protection Branch. On-Site System-Derived Nutrients in a Piedmont Watershed of North Carolina – Ongoing 2015

This study is an ongoing collaborative project between the N.C. Department of Health and Human Services (DHHS), East Carolina University and North Carolina A &T State University (N.C. Department of Health and Human Services, 2015, in prep). The purpose of the study is to assess cumulative nutrient loadings from onsite wastewater treatment systems in the Lick Creek watershed, a subwatershed in the Falls Lake watershed. The study will include an assessment of nutrient delivery to Piedmont streams from properly functioning septic system discharges and overland surface flow from discharging sand filters. The overall project goals are to collect onsite wastewater treatment system nutrient transport field data and to evaluate nutrient loading at the watershed scale using the Soil and Water Assessment Tool model (SWAT-Septic). Final results are projected in 2016.

The Division is currently working with stakeholders and the Nutrient Scientific Advisory Board to develop guidance for implementing the programmatic approach for remedying malfunctioning systems. The necessary guidance and design standard documentation will likely complete the Division’s “Measures Approval Framework,” which involves public comment and final approval by the Director in 2016. Once completed, the nutrient reduction credit established for remedying malfunctioning septic systems and discharging sand filters will be included in the measures submitted as part of the existing development model program schedule to be approved by the Commission in November 2016.

Next Steps

The Falls Lake regulated community, including the UNRBA and the local governments it represents, continues to work constructively and collaboratively with the Division to advance implementation of the strategy. In the coming year, an important area of progress will be establishment of crediting for a significant number of additional stormwater and other nutrient measures to better enable local implementation of the Existing Development rule requirements. These tools will be included in the existing development model program that will be submitted to the Commission for approval in the next two years.

In a major initiative, the Division is currently in the process of readopting the Falls Lake rules per Session Law 2013-413 (H74) which requires the review and readoption of all of the Division's water quality rules at least once every 10 years. Staff posted draft revisions in early 2015 followed by an informal 30-day comment period including a key stakeholders meeting in May 2015. Staff has just completed additional revisions based on stakeholder comments. The Division and the UNRBA are continuing to work together through the ongoing rules readoption process to address rule revisions that would alter the timing of activities around Stage II. The rules should come to the Water Quality Committee in late 2016 for approval to begin the formal rulemaking process. Final rule recommendations would return to the Commission for adoption in late 2017 or early 2018.

The Division will continue to track attainment of water quality standards and use support in the lake as it continues monthly stream and lake sampling. The UNRBA will also continue to collect watershed data through its monitoring program as they develop a revised lake model to inform an evaluation of potential strategy revisions for Stage II., which currently begins in 2021.

Under the current rules, the next Falls Lake status report is due to the Commission in 2021 and will be followed by a special report in 2025 that will evaluate the effects of Stage I implementation on water quality in the lake and the feasibility of meeting Stage II goals. In this report the Division would also provide any recommendations for rule changes pertaining to Stage II.

Appendix 1: Scope of Report

The scope of this report is detailed in 15A NCAC 02B .0275 (b)-(e) as provided below:

(5) ADAPTIVE IMPLEMENTATION. The Commission shall employ the following adaptive implementation plan in concert with the staged implementation approach described in this Rule: …

(b) The Division, to address resulting uncertainties including those related to technological advancement, scientific understanding, actions chosen by affected parties, loading effects, and loading effects of other regulations, shall report to the Commission and provide information to the public in January 2016 and every five years thereafter as necessary. The reports shall address all of the following subjects

(i) Changes in nutrient loading to Falls Reservoir and progress in attaining nutrient-related water quality standards as described in Sub-Items (5)(a)(i) through (vi) of this Rule;

(ii) The state of wastewater and stormwater nitrogen and phosphorus control technology, including technological and economic feasibility;

(iii) Use and projected use of wastewater reuse and land application opportunities;

(iv) The utilization and nature of nutrient offsets and projected changes. This shall include an assessment of any load reduction value derived from preservation of existing forested land cover;

(v) Results of any studies evaluating instream loading changes resulting from implementation of rules;

(vi) Results of any studies evaluating nutrient loading from conventional septic systems and discharging sand filter systems;

(vii) Assessment of the instream benefits of local programmatic management measures such as fertilizer or pet waste ordinances, improved street sweeping and the extent to which local governments have implemented these controls;

(viii) Results of applicable studies, monitoring, and modeling from which a baseline will be established to address changes in atmospheric deposition of nitrogen;

(ix) Recent or anticipated changes in regulations affecting atmospheric nitrogen emissions and their projected effect on nitrogen deposition;

(x) Results of any studies evaluating nutrient loading from groundwater;

(xi) Updates to nutrient loading accounting tools; and

(c) The Division shall submit a report to the Commission in July 2025 that shall address the following subjects in addition to the content required elsewhere under this Item:

(i) The physical, chemical, and biological conditions of the Upper Falls Reservoir including nutrient loading impacts;

(ii) Whether alternative regulatory action pursuant to Sub-Item (5)(g) would be sufficient to protect existing uses as required under the Clean Water Act;

(iii) The impact of management of the Falls Reservoir on water quality in the Upper Falls Reservoir;

(iv) The methodology used to establish compliance with nutrient-related water quality standards in Falls Reservoir and the potential for using alternative methods;

(v) The feasibility of achieving the Stage II objective; and

(vi) The estimated costs and benefits of achieving the Stage II objective;

(d) The Division shall make recommendations, if any, on rule revisions based on the information reported pursuant to Sub-Items (b) and (c) of this Rule;

(e) In developing the reports required under Sub-Items (b) and (c) of this Rule, the Division shall consult with and consider information submitted by local governments and other persons with an interest in Falls Reservoir. Following receipt of a report, the Commission shall consider whether revisions to the requirements of Stage II are needed and may initiate rulemaking or any other action allowed by law;

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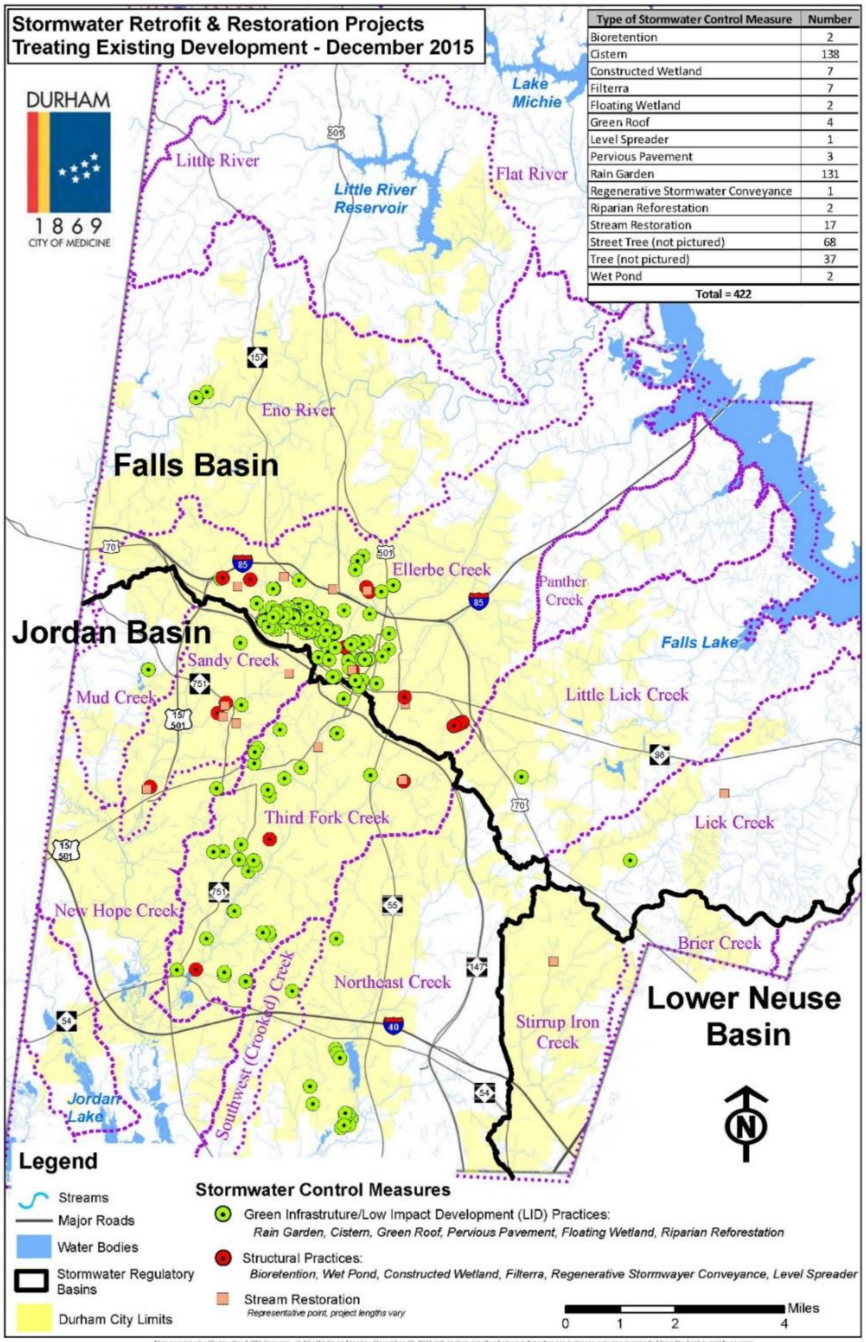
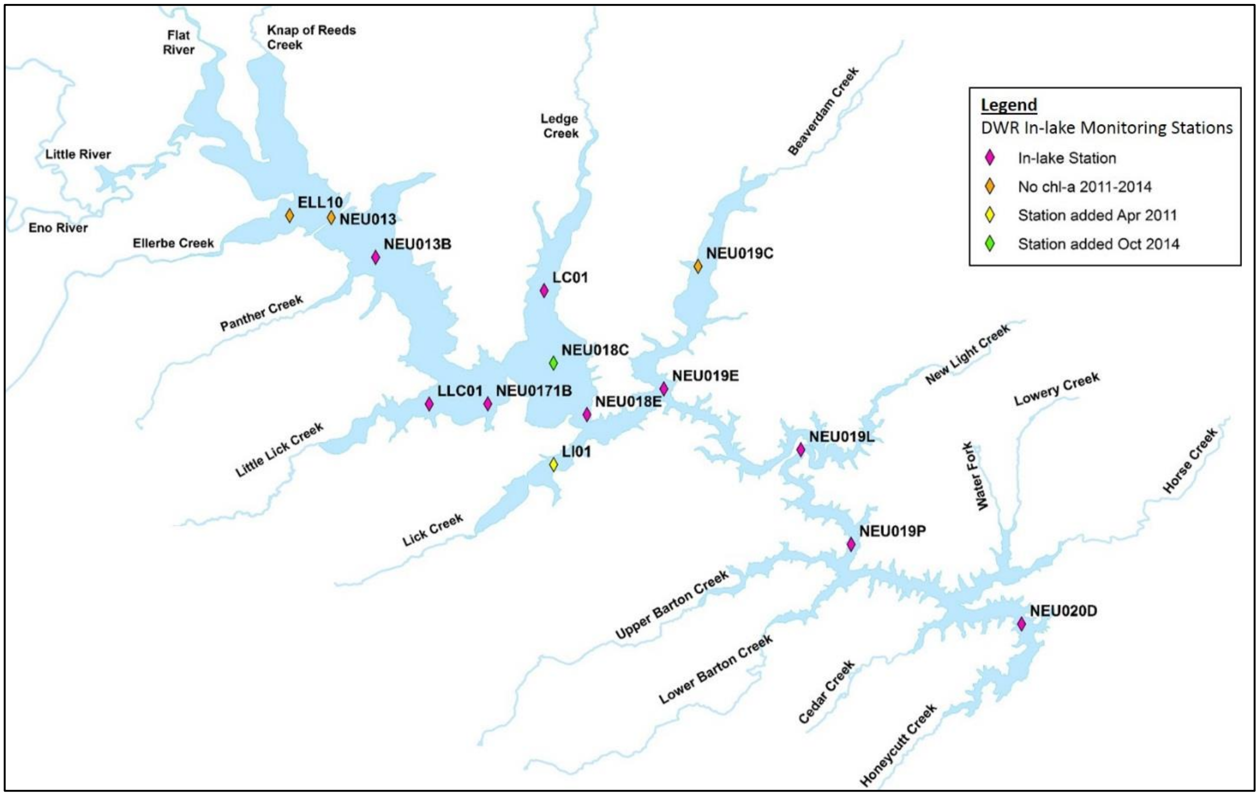
Appendix 4: Durham Stormwater Retrofit & Restoration Projects



Appendix 5: Lake Monitoring Methodology Changes since 2006

The figure below shows the locations of Division in-lake monitoring stations. For three stations (ELL10, NEU013, and NEU019C), there is no chlorophyll *a* data available for the post strategy time period. Station ELL10 was a temporary station used to help support model development and station NEU019C is only sampled during the 5-year basin planning cycles. Chlorophyll *a* is not regularly sampled at station NEU013. Station LI01 was added in 2011 to help evaluate progress towards meeting strategy goals and station NEU018C was added in October 2014.

DIVISION MONITORING STATIONS IN FALLS LAKE.



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